



THE GANGES DELTA

KANANGOPAL BAGCHI

DEPARTMENT OF GEOGRAPHY, CALCUTTA UNIVERSITY



Originally published in 1944
by
University of Calcutta,
Calcutta

Re-print edition published by
Mrs. Anita Bagchi
Falt - 4R/1
Beleghata Sarobar Housing Society
25C, R. M. D. Garden Lane
Kolkata - 700010
India
Phone : 033-2363 0610

Price : Rs. 500.00

BCU 4121
GS 5753

Printed by
Mehta Fine Art Press
20 Balmukund Macker Road
Kolkata - 700 007



GOVERNMENT OF WEST BENGAL

I am happy to know that Professor Kanan Gopal Bagchi's landmark book *The Ganges Delta* published in the year 1944 by the Calcutta University is being reprinted under the aegis of his wife Smt. Anita Bagchi. *The Ganges Delta* will be as relevant today as it was at the time it was first published, being an immensely informative and authoritative technical narrative of the volatile Ganga basin. This reprint will benefit not only the research scholar but also the lay reader in obtaining valuable knowledge and information regarding the Delta.

If our Universities delve into their libraries and archives to identify, restore and reprint such rare and valuable books, they will be doing a service to scholarship.


Gopalkrishna Gandhi

24 November, 2005

Raj Bhavan

Kolkata



Prof. Asit Kumar Banerjee
Vice-Chancellor
University of Calcutta



Teleguage No. { 2241-3288
2241-3071
2241-4984
Fax No. 91-33-2241-3288
SENATE HOUSE
KOLKATA - 700 073

I have great pleasure in presenting the reprint of the book entitled "The Ganges Delta" authored by Professor Kanan Gopal Bagchi, former Head of the Department of Geography, University of Calcutta. The first edition of the book was published in the year 1944. I feel proud to mention here that Professor Bagchi was associated with the University of Calcutta for a long time. By bringing out the reprint of the book we get the opportunity of paying our tribute to one of the outstanding teachers of our University. The proposal for the reprinting of "The Ganges Delta" was initiated by his wife Mrs. Anita Bagchi. We are grateful to Mrs. Bagchi for taking the initiative for reprinting the book.

I believe that the book will be used widely by students, researchers and teachers and will continue to be a prime source of knowledge about its subject matter.

A. K. Banerjee
(Asit Kumar Banerjee)

November 21, 1985

Vice-Chancellor



ACKNOWLEDGEMENT

With the blessings of Almighty, we have come out with the reprint of the Ganges Delta, authored by Late Professor Kanangopal Bagchi, former Head of the Department of Geography, Calcutta University. We are grateful to his Excellency Governor of West Bengal Shri Gopal Krishna Gandhi for bestowing us with his message. We are indebted to Calcutta University for kindly giving us permission for reprinting the book. We are grateful to the Vice-Chancellor, Calcutta University for his encouragement and the message.

Born 1918 Professor Kanangopal Bagchi joined the Post Graduate department of Geography, Calcutta University at its inception in 1941. He was Professor and Head of the department during the seventies and early eighties. Professor Bagchi joined the Technical Advisory Committee set up by the Planning Commission, Government of India in 1959 for a diagnostic survey of the Damodar Valley Region. He was honoured National Lectureship by the U.G.C. in 1981. Professor Bagchi was the President of Geographical Society of India from 1971 to 1987. Professor Bagchi was the President of Institute of Landscape, Ecology and Ekistics till his last date. He was collaborating editor of the journal of Science and Culture from July 1949 to 1976.

Professor Bagchi worked with many Scientists of note. He



had collaborated with Professor N.K. Bose in Prehistoric excavations in Mayurbhanj, Professor M.N. Saha in Geo-hydrological studies of river basins, Professor S.P. Chatterjee in Diagnostic Survey of the Damodar Valley Basins. He was associated with the department of Archeology and Musiology, Environmental Science of the university of Calcutta for decades.

Professor Bagchi has also organized and directed a diagnostic survey of the state of West Bengal a research and development project sponsored by Government of West Bengal. He was principal Investigator of the project "Scio-Economic maladies created by deteriorating hydro-fluvial region of the Ganga and to suggest measures for their amelioration" which was a part of the Integrated Research Programme carried out by fourteen universities located in the Ganga Basins sponsored and funded by the Environment Research Committee and the Ganga Project Directorate, Ministry of Environment & Forest, Govt. of India.

What is evident from his plethora of papers, is his vast knowledge and profound depth regarding rivers, especially, the Ganga. Professor O.H.K. Spate and A.T.A. Learmonth in their book entitled 'India and Pakistan' (Published in 1967, third edition printed in Great Britain) has referred to the above mentioned as an authentic work in the study of deltaic system, quote – There have been many attempts at defining the Delta, most of which appear decidedly odd to a geographer. No purpose would be served by reviewing



them here ; this has been done by Bagchi, and on the whole his delimitation and sub-division appear valid, and in fair conformity with Strickland's distinction between 'the area of transcendent deposition', the delta, and 'that of corrasion', the paradelta. (Page 571, Chapter 19).

Not only Ganga other rivers have also been subject to much of his deliberations. Course characteristics of these rivers find mention in his works as do the various ways in which their potentials may be tapped and optimally utilized. His expertise in the various technicalities of a river system is unsurpassed. His studies on the basins of the Mahanadi, Damodar, Mayurakshi, Kosi and the Godavari were published in the pages of 'Science and culture', the leading scientific journal from Calcutta.

Apart from his scholastic qualities his devotion to the cause of motherland reigned supreme. He was an ardent follower of MAHATMA GANDHI, and was closely associated with him when Gandhiji was in NAOKHALL. He was actively associated with the publication of the "HARIJAN".

We are grateful to Shri S.P. Dasgupta President Geographical Society of India & Ex-Director NATMO, Professor Bireswar Banerjee former Head, Department of Geography, Calcutta University, Professor Chittaranjan Pathak, former Head, Department of Architecture and Regional Planning, IIT Kharagpur, Professor H.R. Betal former Head of the Department of Geography, Calcutta University, Professor Subhash Chandra Mukherjee, Ex-



Head of the Department Geography, Calcutta University for their kind guidance. We are also grateful to Geographical Society of India, Institute of Landscape, Ecology and Ekistics, Indian Science News Association in extending cooperation for preparing the list of Professor Bagchi's articles published in the respective journals.

Lastly I am thankful to my family members, Dr. (Mrs) Jahnabi Mookherjee, Ms Basabi Bagchi, Shri Kausik Bagchi, Shri Somnath Mookherjee and Mrs. Urmi Bagchi for their active cooperation. Shri Vinayak Mookherjee is appreciated for his active participation. Master Kanad Bagchi and Master Kaustav Bagchi are remembered for their sweet inspiration.

My sincere thanks also goes to Shri Ashok Mehta.

MRS. ANITA BAGCHI

CONTENTS

FOREWORD ..	..	..
INTRODUCTION ..	..	..
I. DEFINITION OF DELTA ..	..	1
II. DELTAIC REGION IN BENGAL ..	..	8
III. DELTAIC FORMATIONS ..	..	21
IV. FORMATION OF THE GANGES DELTA		39
V. STAGES IN THE FORMATION OF THE GANGES DELTA ..	..	50
VI. DISTRIBUTION OF POPULATION : AN INDEX OF THE REGIONAL BALANCE OF MAN ..	..	72
VII. DENSITY IN RELATION TO ECOLOGY		76
VIII. EARLY ACCOUNTS OF POPULATION		79
IX. DEPOPULATION OF THE LOWER PART OF THE DELTAIC REGION ..	..	85
X. EARLY ESTIMATES OF POPULATION		94
XI. ECOLOGICAL CONDITIONS IN THE MORIBUND DELTA ..	..	100
XII. ECOLOGICAL CONDITIONS IN AN AREA PARTLY MORIBUND AND PARTLY ACTIVE ..	..	131



CONTENTS

XIII.	ECOLOGICAL CONDITIONS IN A MATURE AREA	136
XIV.	ECOLOGICAL CONDITIONS IN AN ACTIVE AREA	148
XV.	DISTRIBUTION OF POPULATION IN RELATION TO ECOLOGY: A REVIEW	154

FOREWORD

Every change in the economic organisation of a country brings about changes in the distribution of its population. Thus if a people who formerly lived by trade along river-ways gives it up in favour of trade by railroads, there will be a necessary migration of those sections of the population concerned with trade, from the neighbourhood of river courses towards railway lines. In a similar manner if the physical condition of a region is altered through natural causes, men will give up their old ways of life and adopt new ones, followed by a corresponding redistribution.

Some of the rivers of Bengal in the deltaic region, are known to have altered their course within historic times, others have shrunk up considerably within living memory. This has been attended by agricultural decline and the growth of malaria in particular localities. The present work deals specially with the dynamics of the Ganges delta and the growth and decay of population during the last fifty years in this particular region of Bengal. The author has naturally worked under certain limitations. Censuses are not available beyond 1871, and there are no reliable maps to show accurately by comparison, how the courses of streams or their volume has changed in course of time. So the author has had to depend on general observations regarding the rivers left by past observers. He has succeeded in establishing a correlation between changes in their condition and the rise and fall of population in a more or less satisfactory manner.

There are, however, deeper problems involved in the history of population in any region. It is not unlikely that changes in the economic interest of a people and a migration of selected sections of the population, as well as capital,

FOREWORD

may itself be the cause of the decay of old irrigation systems and of agricultural decline. Just as the physical may lead to the economic, so the economic or political may give rise to profound modifications in the cultural landscape of a region.

It is good that the author has not tried to delve into these deeper problems at the very start. He has tried to be accurate and has spared no pains to present his case clearly and within brief compass. Moreover, he has no pretensions of being exhaustive. If the work succeeds in drawing attention to the numerous problems connected with demographic history of Bengal, his labours will be amply rewarded. It is only when other scholars feel interested and approach the problems from different angles, that we can hope to give a fuller picture of what has happened to our land in course of the last two hundred years.

ANTHROPOLOGICAL LABORATORY,
CALCUTTA UNIVERSITY,
September, 1943.

NISMAL KUMAR BOSE

INTRODUCTION

The problems of the deltaic region in Bengal, for which the name Ganges Delta has been proposed, have been studied by various authors from different points of view. Dr C A Bentley was primarily concerned with the problem of malaria in Bengal and in course of his study, 'Malaria and Agriculture in Bengal,' brought out the intimate relation between health and agriculture in the deltaic region. Instead of suggesting temporary remedies through medicine alone, Dr Bentley made his attack at the very root of malaria by suggesting restoration of the over-flow irrigation in Bengal. This, he believed, would restore fertility of soil, increase productivity and improve the health of the province.

Sir William Willecocks, next made a thorough study of the problem of irrigation in his book 'Ancient System of Irrigation in Bengal.' In course of his survey Sir William was convinced of the artificial nature of most of the waterways of Bengal which are now called dead rivers because of their decaying conditions. Willecocks maintained that these streams had been laid down in positions according to a plan and designed to carry flood water of the Ganges and that they could be restored to their former prosperity at reasonable cost and effort. He also warned us against improper use of and unplanned interferences with these channels of over-flow irrigation in future.

From actual field experience and other evidences, both Dr Bentley and Sir William, have maintained that agriculture, health and prosperity of the people in deltaic regions, depend mainly on an elaborate system of over-flow irrigation that flushes the country with its salt water from the rivers. The efficiency of this, no doubt, depends on the active condition of the rivers.



INTRODUCTION

Major portion of internal trade in Bengal, until lately used to be carried through rivers. A number of books, dealing with the shifting nature of trade and commerce along with the decay of rivers have also appeared subsequently. The latest addition to the list is a recent study of the *Rivers of Bengal Delta* by S. C. Majumdar. Mr. Majumdar has mentioned the decaying nature of the rivers of Bengal, the reasons for which he ascribed to human interferences in the past and lack of initiative in the present. The remedy seems to be yet far off for vested interests stand in the way. Notwithstanding Mr. Majumdar has tried to give a long range view of the problem by advocating an inter-provincial control of the rivers and the formation of a scientific research organisation that may advise on proper methods of irrigation and river training. In course of his studies of river dynamics with a view to prevent disastrous floods and choking of river beds through alluviation, Mr. Majumdar has arrived at some of the conclusions also reached independently by the author of this book. Mr. Majumdar's book appeared in the market when the manuscript of this book was in the press and it is rather interesting to find that the stages in the formation of the Ganges delta have been worked out in a similar way in both the books.

Greater stress has been laid in the present work, however, to the dynamics of the Ganges delta but this has been to emphasize how it has influenced the nature of the distribution of population in it for the last fifty years. In course of treatment it was found necessary to define the extent of the deltaic region in Bengal and a name that would be appropriate for it. The extent of this deltaic tract is confined within the two farthest distributaries of the Ganges, i.e., the Bhagirathi and the Padma-Meghna Channel. The name that has been proposed is the 'Ganges Delta'. In case of all other deltas in the world, nomenclature is done



INTRODUCTION

after the name of the parent river and never after the political unit to which the deltaic tract belongs. There is no reason why an exception should be made in case of the deltaic region in Bengal.

The stages in which this delta came to be formed and the hydrographic characters in its different portions, provided a basis on which the Ganges Delta has been divided into moribund, mature and active parts. But the central object in studying the hydrography of the Ganges Delta was to bring out in details the nature of the distribution of population in different parts of the deltaic region and how far it is influenced by *geographical* conditions. The elements of physical environment determine more or less the nature of irrigation, the productivity of the land and the salubrity of the area. This physical environment, in the case of the Ganges Delta, is found to be largely composed of and dominated by the rivers. So that a study of the character of the rivers provide a key into the ecological conditions. Apart from this physical element, there are also socio-political factors that enter into the consideration of the ecology and determine ultimately the nature of distribution of population in its confines.

It has been thought proper to split up these different elements constituting the ecology, so that the role of individuals might be given some emphasis. This may lead to over-emphasis in particular cases, but the balance, it is hoped, would be restored, when all the aspects are developed. In the present work only the physical elements have been considered and an attempt at correlation of these with the nature of the distribution of population in fifty years, has been made. Future works might be directed to socio-economic factors including the growth and operation of capital in urban areas that have also greatly influenced the pattern of the density of population.

It is a privilege for the author to remember, in this connection, the help, sympathy and co operation of different

INTRODUCTION

libraries, friends and students who have unstintingly responded. The author is particularly grateful to Mr. Jatindra Mohan Dutta, M.Sc., B.L., for his suggestions on population study, to Mr. Abaninath Chaudhuri, student, Presidency College, Calcutta, for going through the proofs and giving his helpful criticisms to Misses Tapasbala Chatterjee, B.A., and Binapani Dasgupta, M.A., for their valuable suggestions and the designing of the illustrations and to Mr. Anilkumar Dutt for the drawings. It would not have been possible to have the book written and subsequently to have it published now, but for the encouragement and opportunity, so kindly afforded by the University of Calcutta, including the University Press.

GEOGRAPHY LABORATORY,
CALCUTTA UNIVERSITY,
ASUTOSH BUILDING,
9th August, 1913. }

KANANGOPAL BACHHI

DELTAIC REGION

Showing Hydrographic Features



ON OF BENGAL

ures And Deltaic Stages

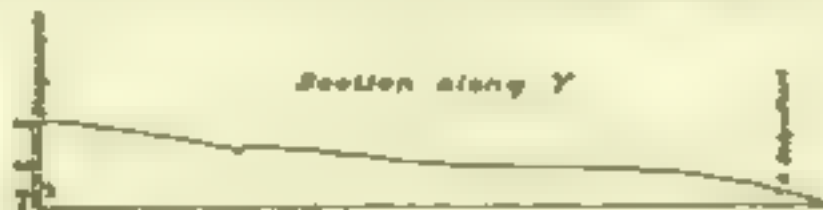
Miles



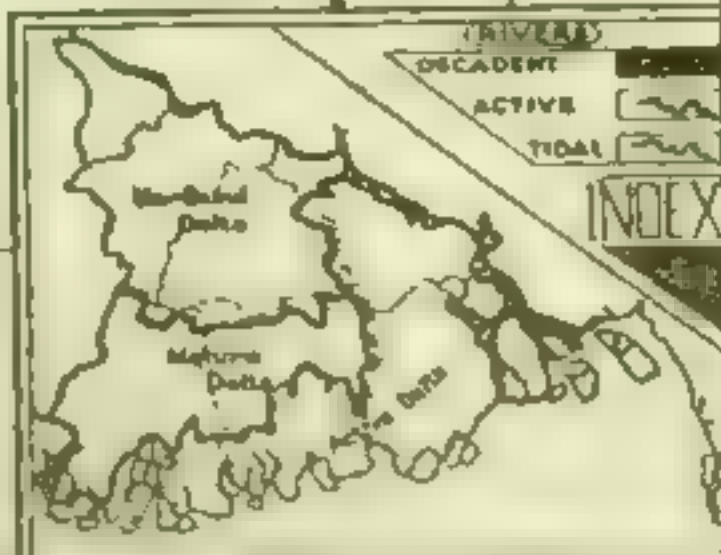
Section along X



Section along Y



Diagrammatic shape of the Delta



INDEX

Mangrove Forest

CHAPTER I

DEFINITION OF DELTA

1. While proceeding to study the dynamics of the deltaic region in Bengal and how far they have affected the distribution of population in it for the last fifty years, some confusion was encountered as to which portions of Bengal should be considered as *deltaic*. It is indeed true that the deltaic region in Bengal has already been studied by several authors from different aspects, but the difficulty is that no two of them agree as to its demarcation. Some of them, evidently, were not very particular as to what they meant by the term *delta*, and in consequence, as many demarcations of the deltaic region have sprung up as there were authors. And to add to our confusion, all sorts of areas, from the political boundary of the Province down to localised regions, have been included within the scope of the word *delta*. To avoid further confusion, it has become necessary, therefore, to be precise as to which portions of Bengal are to be called *deltaic*.



2. But before we actually proceed to do this, it would be helpful for us to know what is indicated by the term *delta*. There is no doubt that the word *delta* in its general use has lost much of its original significance. While admitting that deltaic regions are essentially riverine deposits, there seems to be little agreement on the point of how much of a riverine tract should be included within its confines. Some would like to restrict this term to the land a river might have acquired by way of reclamation from the sea or lake,* while others would draw no distinction between deltas and alluvial fans, perhaps for the reason that each partakes, to a great extent, of the character of the other. This last tendency is most prevalent amongst those who have been concerned with the deltaic region in Bengal. There is a third view which considers it best to abide by the original significance of the term.

3. The name *delta* was first applied to the arcuate, fan-shaped deposit formed by the river Nile at its confluence with the sea. The shape of the land, between the two extreme distributaries and the sea, resembled

* It is less definite but perhaps truer to regard the upstream border of the land reclaimed from the sea or lake by the river deposits as the head of the delta.—R. D. Sahabury, *Phytogeography*, p. 173.

the Greek capital letter Δ, and hence was named after it. Subsequently, the study of other rivers elsewhere also showed that a similar phenomenon is common to them, and so the term *delta* came to signify all such formations at the confluence of the rivers with the sea. The scope of the word increased still more when it was found that exactly similar deposits were also formed when rivers emptied into lakes. So that, to-day, by the word *delta* is meant "a deposit, partly subaerial, built by a river into or against a body of standing water" (Nevin's modification of Barrell's definition), and henceforth deltaic regions came to be regarded as distinct portions of riverine tracts. Detailed work by geomorphologists, however, showed that many of the characters which were at one time considered to be confined to the deltaic region alone also extended upstream in the alluvial fans, wherefore, to keep precision and preserve the definitive character of the term *delta*, some clear demarcation was felt necessary.

4. According to Sir Archibald Geikie (*Text-book of Geology*, Vol. I), "when a river enters the deltaic portion of its course, it assumes a new character—in the previous parts of the journey it is augmented by tributaries, but now it begins to split up into branches." Geikie then demarcates the deltaic portion from the non-deltaic area on the basis of

Geikie on Delta

the hydrographic characters ; so that, according to his view, a *deltatic region commences from the point where distributaries begin to be given off.*

5. R. D. Salisbury draws a comparison with alluvial fans. " In both cases," he observes, " the principal deposit is concentrated at the point where the velocity is checked more completely, and the debris accumulates (at the outset) below the surface of standing water. In form the delta differs from alluvial fan in that its edge has a steep slope. . . That part of the delta above the surface of water in which it is built is like a flat alluvial fan." He, therefore, feels the necessity of giving a demarcation to the upper region of the delta, which he prefers to be *the point from which distributaries begin to be given off*, though he maintains that such demarcation is rather conventional (*Physiography*).

6. Longwell, Knopf and Flint (*Text-book of Geology*, Pt. 1 *Physical Geology*), P. G. Worcester (*A Text-book of Geomorphology*), and C. L. White and G. T. Renner (*Geography : An Outline of Human Ecology*) all express the same view regarding the demarcation of the deltatic region. All of them lay emphasis on the point that the deltatic tract is the area enclosed by the distributaries of a river and that it commences from the point furthest upstream whence the

distributaries begin to be thrown off. A. K. Lobeck (*Geomorphology*), in describing the Nile delta, considers it to commence from Cairo, which, according to him, is its apex. Cairo is situated exactly at the point where the Nile splits up into the first two distributaries.



The Nile Delta

7. The common points of agreement amongst the authors just cited, then, may briefly be summed up as (i) that deltaic regions have some characters in common with the alluvial fans or flood plains further upstream; (ii) that some differences are still to be found between them; and (iii) that a convenient demarcation, however arbitrary, would be necessary for all workers in this field, (iv) which demarcation

would be the point whence distributaries begin to be given off. A *delta*, therefore, is that portion of a riverine deposit demarcated on one side by the sea or lake in which the deposit is formed and on all others by the distributaries of the stream, its apex being at the point from which the splitting of the stream begins.

8. It is now known that deltas of all the rivers of the world do not have this arcuate shape as the delta of the Nile. The deltas of the Mississippi and the St. Clair, for example, have

All deltas are not
like in shape



The Mississippi Delta

the appearance of a bird's foot and hence are known as *Bird's Foot deltas*. Deltas of those

rivers draining into estuarine tracts may have other shapes depending on the forms of the estuaries. These are known as *Estuarine deltas*. But since the delta of Bengal—or the Ganges delta as it should be called—does not resemble any of the above, discussion of Bird's Foot or Estuarine types need not detain us here. But, be it noted, that even in case of the Mississippi delta, the deltaic region is that portion built up by the anastomosing distributaries of the Mississippi and that its northern boundary has been considered by A. C. Lawson (*Mississippi Delta*, Bull. Geol. Soc. Amer., Vol. 53, No. 8, 1942) to be approximately at latitude 32° 30' N. This boundary, though sinuous, marks the region where the streams are in the nature of distributaries. In case of the deltaic region of Bengal, no such difficulty arises, as it is an arcuate one.

CHAPTER II

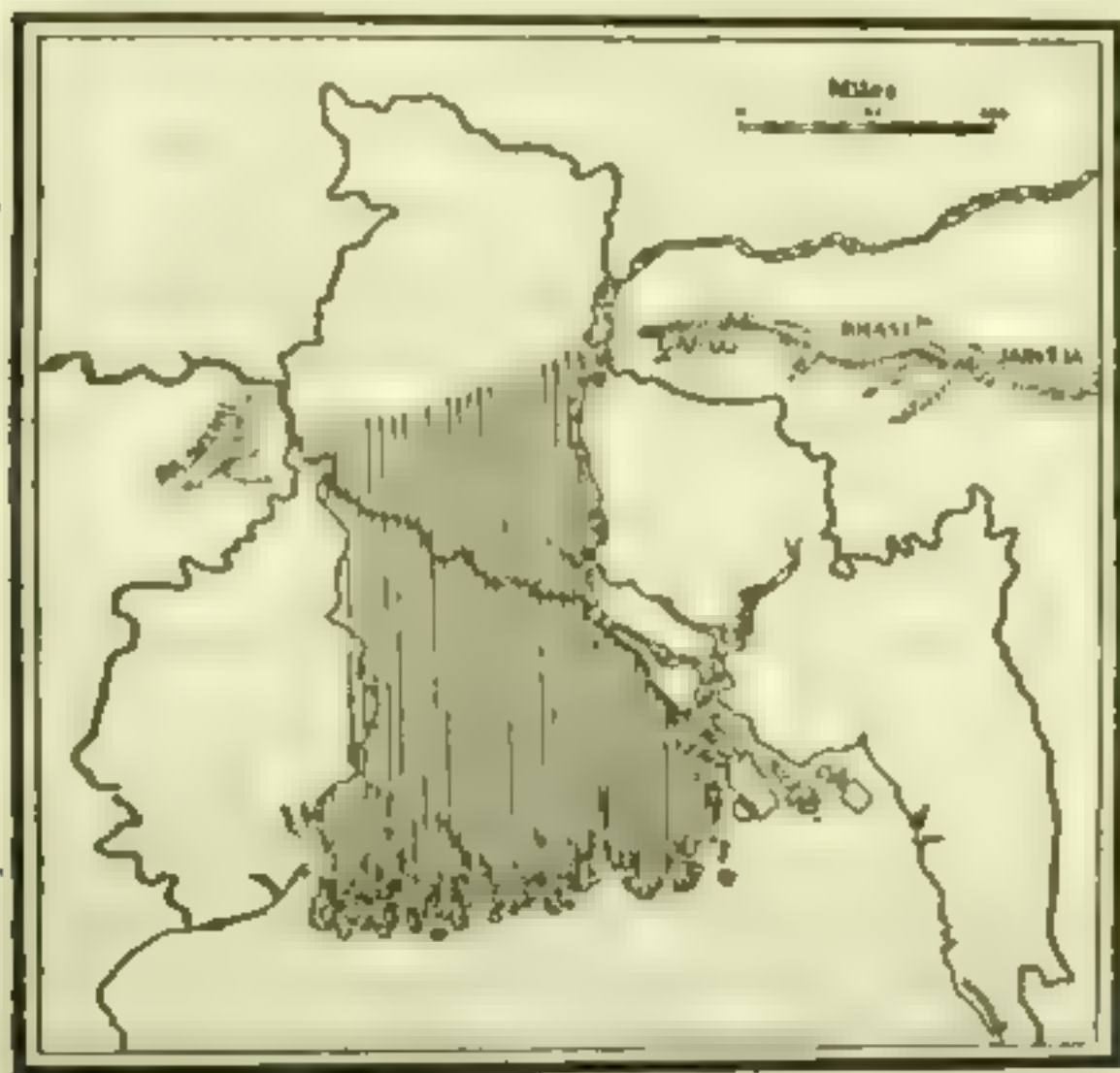
DELTAIC REGION IN BENGAL

9. Let us now examine which portions of Bengal have been considered deltaic by various workers in this field, and consider how far they are tenable in the light of the definition that has been accepted by general agreement.

In the *Proceedings of the Asiatic Society of Bengal*, 1870, pp. 47-51, Dr. Thomas Oldham, the senior most worker in this field, makes the following observation, "I suppose no one will hesitate to acknowledge that the whole country, including the Sundarbans proper, lying between the Hooghly on the west and Meghna on the east, is only the delta caused by the deposition of the debris carried down by the rivers Ganges and Brahmaputra, and their tributaries."

10. "In the case of the Ganges river," writes Dr. (afterwards Sir) C. S. Fox, in his *Physical Geography for Indian Students*, "deltaic portion begins a little below Rajmahal and close to the ancient town of Gaur, now in ruins, where the first distributary, the Bhagirathi, which lower down becomes the

Hooghly River of Calcutta, leaves the main stream. Such new channels naturally tend to form secondary deltas of their own, and it is in this manner that the Ganges delta in Bengal has been formed."



The Ganges Delta (according to Fox)

11. Both Oldham and Fox consider the deltaic region as commencing from the point where the Ganges has given off the distributary

Bhagirathi. Its extent has been considered to be bounded by the Bhagirathi on the west and the Meghna (the combined channel of the Ganges and the Brahmaputra) on the east, spreading up to the sea face, including the Sunderbans. But they are not precise as to what should be taken as the northern boundary. While trying to make an estimate of the area of the Ganges delta, Dr. Fox considers a line joining the Rajmahals with the south-west corner of the Garo hills as the northern boundary. To me this 'northern boundary' appears unreasonable, as it includes a portion of the alluvial fan to the north of the Ganges (Padma channel).

12 In his essay on *Romance of the Rivers of the Gangetic Delta*, Rai Bahadur G. C. Chatterjee, in defining the deltaic region, makes the suggestion that "For this purpose, to make out a clear opinion of the point at issue, it will be best if we imagine the Gangetic delta as an island, triangular in shape, the apex being at the junction point of the Bhagirathi and the Ganges at Geria, the western boundary line being the Bhagirathi-Hooghly, the eastern boundary is a curvilinear line formed by the bed of the Ganges from the apex to the mouth of the Garo Madhumati and the bed of the latter river, the base line being formed by the sea-board between the outlets of the Hooghly and the Madhumati in the Bay of Bengal." This area,

says he, "is almost conterminous with the Presidency Division."

13. As regards the western boundary and the apex, i.e., the point from which the deltaic region commences, Chatterjee, Fox and Oldham have no difference. The difference comes in when Chatterjee tries to consider the Garai-Madhumati channel as the eastern limit of the deltaic region. This seems entirely illogical. The tract between the Garai-Madhumati and the Meghna right up to the sea-board has all the features common with the western portion of the delta, and it has been formed by a similar process. Moreover, this tract is also included within the distributaries of the Ganges and presents a similar sea face. There is no reason, therefore, why this portion should not be included within the deltaic region: Oldham and Fox were perfectly justified in doing so.

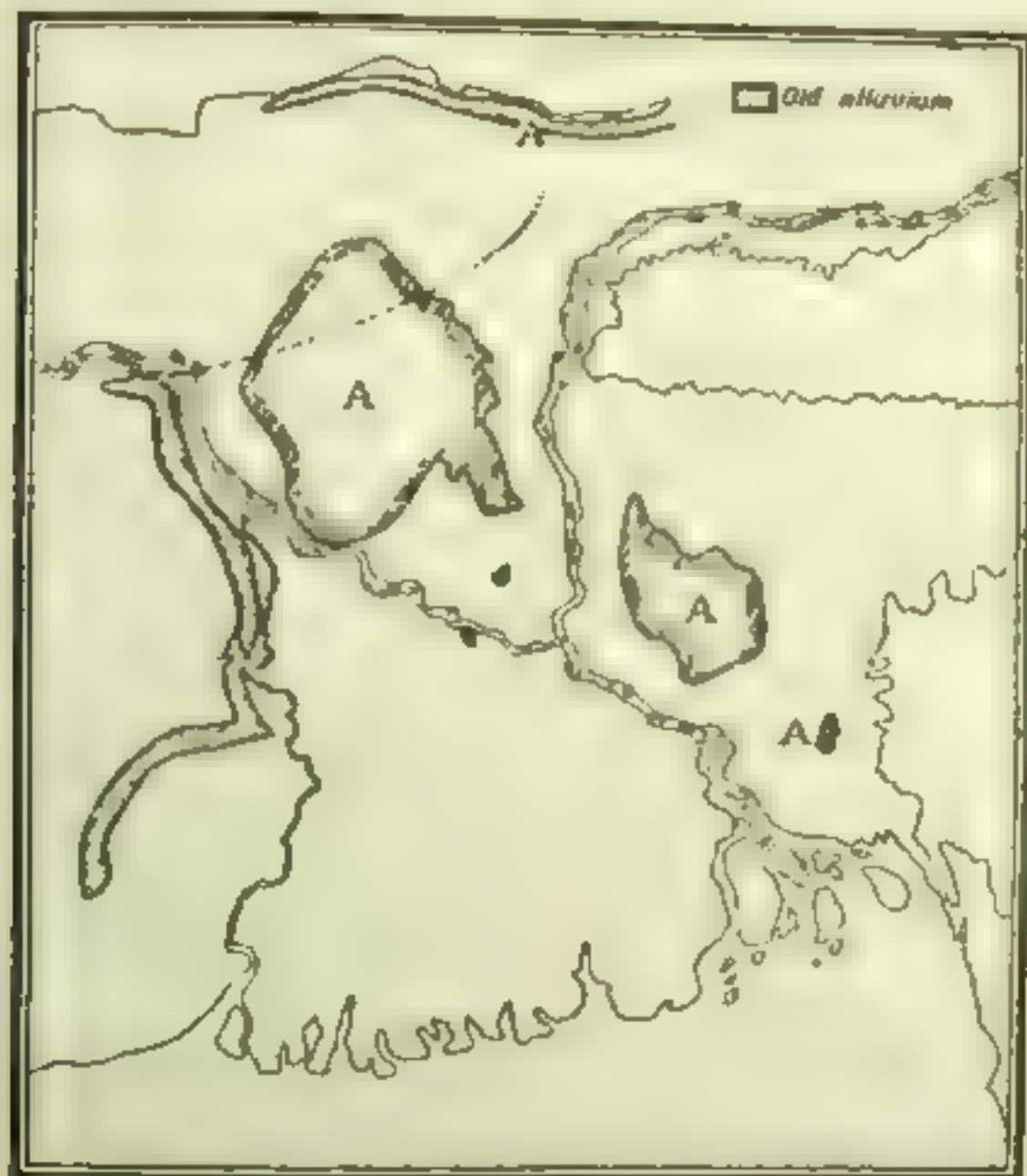
14. Dr. Strickland, who has worked for a considerable period in Bengal in connection with the problem of malaria, expresses the opinion that it is unhappy to give any static significance to the term delta, so as to include only the "region within which rivers give off distributaries." He contends that the process is a dynamic one, and so, "as the general profile of the land ever becomes flatter, that character *pari passu* is seen to develop further and further inland . . . (apex receding

sourceward) . . . so that for definitive purposes this proposal, too, is unsatisfactory."

15. Dr. Strickland would rather like to call the deltaic region "as the area of transcendent deposition in contradistinction from that of corrasion" as prevailing in the rest of the fluvial plain. "Thus, in Bengal, presuming that one would wish to define the delta as the area of transcendent deposition in contradistinction from that of corrasion, there is the practical difficulty that there is, at the moment, that great tract, the so-called plains, which is really part of the land undergoing degradation, i.e., where corrasion is prevailing but the true nature of which is seldom recognised, because superficially it is very slightly different from the 'depositing' area, the two antithetic regions, the plains being *degraded* and the plains undergoing *elevation* being in common parlance *lumped together as the 'delta'*." If, then, that equivocal area, or the plains undergoing degradation, should be excluded from consideration of any matter pertaining to the more seaward tract, he apprehends, "the *public sense would be violated*,"* while, if it be included, although it be a tract of degradation, it would be equally logical, though quite impractical, to consider with it the sediments along the mountain streams." Here he refers to a map with the

* Italics are mine.

note : The map shows clearly how the so-called plains of Bengal are the floors of degraded areas lying between masses of older alluvium A. A. A."



The Ganges Delta according to Strickland

16 "As, then, it has been found impossible to define satisfactorily the term 'Delta,' he proceeds, "and the sequel will show that it is

very essential to have epithets by which to denote the two apposing tracts where respectively deposition or erosion has prevailed, these will hereafter be named Delta and Paradelta.* So that, according to Strickland, that portion of the fluvial plain is delta where there is transcendent deposition.*

17. Fergusson suggested (as quoted by Strickland in his book) "that the use of the gradient of a river might be of some help in demarcating the deltaic region from the rest from the fact that in the former aggradation is more prominent than degradation." The map of Strickland, now, needs scrutiny in this light. The region included within the distributaries of the Ganges (Bhagirathi and Padma-Meghna) and the Bay of Bengal is the only portion where the amount of aggradation is still far in excess of that of degradation. Bordering it on three sides are remnants of older alluvium (see map on p. 13), which indicate that the region surrounding has been formed by degradation, which is still continuing.

18. Besides the region included within the distributaries of the Ganges and the Bay, the term delta has also been extended to other parts of Bengal. Dr Radhakamal Mukherjee,

* Strickland, *Deltaic Formations*, pp. 8-10.

in his book, *Changing Face of Bengal* (p. 116), makes the observation, "Whole of Bengal is a fertile alluvial plain, but this can be divided into four natural regions, according to the extent to which the soil is enriched by silt deposited when the rivers



The Bengal Delta (according to R. K. Mukherjee)

are in flood. These regions are (1) the Old Delta, or (a) West Bengal and (b) Central Bengal, (2) the New Delta, or East Bengal; and (3) the Ganges Brahmaputra Doab, or Northern Bengal."

19. In another book, *The Regional Balance of Man* (p. 70), he writes, "Central Bengal, which is bounded on the west by the Bhagiratha, on the north by the Padma, and on the east by the Madhumati, was formerly the Ganges delta. . . . Eastern Bengal, on the other hand, is hemmed in by the Brahmaputra, the Padma and the Meghna. Where the Brahmaputra rounds the Garo hills, there begins the delta of that river; where the Meghna combines the southern rainfall of the Khasi hills with the western drainage of the watershed between Bengal and Burma, there begins (in Sylhet) a third delta."

20. While writing the above two books, Mukherjee, evidently, had in mind (1) a western delta, represented politically by the Burdwan division, comprising the land to the west of the river Hooghly; (2) a northern delta (of the river Brahmaputra) beginning from where the Brahmaputra rounds the Garo hills; and (3) an easternmost delta thrown up by the Meghna, commencing in Sylhet.

21. Dr. S. G. Panandikar, in his book, *The Wealth and Welfare of the Bengal Delta* (a thesis approved for the Degree of Doctorate of Science in the University of London), considers the "Bengal Delta" as "comprising the districts of Mymensingh, Dacca, Bogra, Pabna, Faridpur,

Mukherjee's demar-
cation Western,
Northern and Eastern
Deltas.

Panandikar's de-
marcation of the Ben-
gal Delta.

Bakerganj, Tippera and Noakhali." It has neither been indicated in the book why the districts of 24-Parganas, Khulna, Rajshahi, Damajpur or the



The Bengal Delta (according to S. G. Panandikar)

tract to the west of the Bhagirathi have been left out, nor the reasons that led Panandikar to adopt such a peculiar demarcation of what he calls the Bengal Delta.

22. Sir William Wilcocks, in his book, *Ancient System of Irrigation in Bengal*, has frequently referred to different portions of Bengal as being deltaic. From a study of his book it appears that, wherever a river overflowed its banks in high floods, and deposited a top dressing of silt, such tracts were considered by Sir William as conforming to the nature of a delta. It is little wonder that the view of a delta engineer of Sir William's reputation is supported by many others, who consider every portion of Bengal, which is alluvial in character, as deltaic, irrespective of the mode of deposition of such alluvium.

23. Different views as advanced by the previous authors as to the extent of the deltaic region in Bengal have been enumerated above. The merits of individual views will now be examined. Considering the geological structure and physiographic features, the greater part of the districts of Bankura, Burdwan, Birbhum and the western half of Midnapur is a continuation of the Chota Nagpur plateau to the east, and the present surface of the region has been derived mainly by a process of degradation of the table-land. The surface is rocky except a top dressing of silt thrown by the rivers in inundation. This region was never reclaimed from the ocean by deposition of sediments, and the rivers yet retain

Sir William Wilcocks
on Delta

West Bengal can
not be considered a
Delta

all the characters of a plateau stream. Bordering the plateau escarpment, forming the eastern half of the Midnapur district, a low lying region characterised by swamps and unhealthy conditions is found extending up to the Hooghly, which partakes of the nature of a deltaic region in some points. But it can be considered more as a 'Piedmont plain,' built up by the Damodar, Rupnarayan and other streams. Moreover, this western tract is not included within the distributaries of any river. So that, judging by the structure, hydrography, origin and land form, this region cannot be included within the present deltaic region of Bengal.

24. The region between the Ganges and the Brahmaputra and that between the Brahmaputra and the Meghna (upper part of its course before combining with the Ganges) have, no doubt, been built up by the materials brought down by the rivers. But these can, at best, be regarded as alluvial fans, and not deltas, for reasons mentioned later in Chapter III.

25. The south-easternmost block of land, comprising the districts of Tippera, Noakhali, Chittagong, Chittagong Hill tracts and Hill Tippera, cannot also be considered deltaic, because they comprise a part of the submontane region. The Chittagong Hill tracts and Hill Tippera are

definitely hilly and the plains of the Tippera, Noakhali and Chittagong districts can at best be composed of alluvial materials washed downhill and deposited subaerially. Moreover, this tract is not included within the distributaries of any



river, nor are the rivers flowing through it in the nature of distributaries.

The mode of formation of deltas in general and the Ganges delta in particular will be discussed in the next two chapters.

CHAPTER III

DELTAIC FORMATIONS

26. When a stream enters a lake or a bay, its current does not cease all at once. The stream persists for some distance, till its momentum is spent up. If the body of the water into which the stream enters be comparatively quiet, the materials carried by it drop off and some of them settle at the bottom. Deposition in standing water The dropping off of the materials is due to the fact that the carrying power of the stream is lost the moment its movement is arrested. But this dropping off of materials is not uniform over the entire floor of the basin receiving the sediments, nor is it uniformly rapid or slow in case of all the delta-building rivers of the world. When the stream enters the lake or the bay, since its central portion pushes on, remaining mobile for some length, the materials first begin to drop off the edges of the moving stream and ultimately *the end* when all current is lost. So, to start with, two banks in the form of embankments begin to grow up, and then the sediments pile

GS 5753

up in the shape of a tongue confronting the mouth of the stream.

27. G. K. Gilbert's investigations into the structure of the deltaic formations in Lake Bonneville reveal the existence of three sets of beds. The earliest beds to be deposited are usually flat and serve to fill up the irregularities, if any, and then form a smooth floor of the basin on which to receive other sets. The next set of beds to be deposited is the fore-set beds, that are rather steeply inclined. This difference in the disposition of the bottom set and fore-set beds is perhaps due to the fact that,



Deltaic Structure (Gilbert)

when the bottom-set was being deposited, the basin was so deep that the layers were not influenced by the stream, and that they partook of the general character of deep-water deposits, in being parallel to the floor. But with the deposition of the bottom-set, the basin has become shallow and so the fore-set of beds were deposited much, as shallow water deposits are formed at inclined positions parallel to the coast. Ultimately, as the basin comes to be nearly filled up, the water of the stream charged with its load spreads



out and causes the top-set of beds to be formed, which, again, are nearly flat. These top-set beds rather partake of the nature of alluvial deposits in flood plains, lying in conformity with the slope of the nearly filled up basin. The existence of such types of bed has also been observed by Lawson in case of Lake Superior and Mississippi deltas. But it should not be supposed that structures of deltas, irrespective of their form, would be alike, or that all deltas would have each one of these three sets of beds. Nevin's experimental study of delta formation in the laboratory shows that, under different conditions of experiment, different sets of beds with different angles of rest are formed.* (O. M. Nevin and D. N. Turner, *Laboratory Study in Delta Building*, Geol. Soc. Am., Vol. 38, 1927.)

28. It has already been mentioned that the materials, as soon as they are brought to the bay or the lake, do not settle all at once. Factors affecting deposition of sediments. The time required for them to settle at the bottom varies for all the streams. This depends, firstly, on the nature and composition of materials

* The place of deposition of any single particle brought by a stream into a body of standing water is in general determined by the point of equilibrium between the horizontal component of the stream's velocity plus the buoying force of the water and the vertical component of the stream's velocity plus the attraction of gravity for the particle. Fore-set, top-set and bottom-set beds, with their different angular relations, illustrate this fundamental principle.—C. M. Nevin.



brought by a stream, secondly, upon whether it is saline or fresh water into which the stream debouches; and thirdly, upon the relative quietness of the basin receiving the sediments. If it be a young stream, besides sand and mud, gravels would be brought down, and it is needless to mention that the heavier the materials, the faster would they settle. But if it be a mature one, as the Ganges, which transports only coarse sand, fine sand, clay and silt, it will take a comparatively longer time for them to settle. The composition of the sediments also has its effects. It takes different times for different proportions of clayey, siliceous or calcareous materials to settle down. Not only this: if the fresh water of the river mingles with the salt water of the sea, deposition is generally hastened by chemical reaction. If the basin receiving the sediments be comparatively quiet, it would permit a greater quantity of materials to be deposited near at hand. The case would be the reverse if the basin be agitated. In the case of the Mississippi delta, Lawson estimates that "one third of the solids goes to the ocean shores and bottom beyond the limits of the delta, and that two thirds, or one-half of the total erosional product, goes to the construction of the delta." In case of the Nile delta, again, it is believed that the seaward extension of its floor has received a check for all time to come, due to the sweeping nature of the

currents just beyond the existing limit of the delta.

29. As the river continues to bring in sediments and they spread out on the bottom of the unagitated bay or lake, a submerged platform is built up, in whose structure, as already mentioned, is reflected the presence of bottom-set, fore-set and top-set beds. This submerged platform develops gradually, upwards and seawards, till its height reaches up to the sea level. When this happens, an important change occurs in the hydrographic form of the river. So long, the stream, after meeting the sea, could force its way only a little distance by its own momentum. Then it had to die away. But now it gets a platform on which to wander across, so that its track is lengthened. But yet, the land has not been firm and has just reached the sea level so that there is still a film of water over it.

30. Let us, at this stage, follow the river upstream a little above the point where it meets the sea. A mature and long established river, like the Ganges, carries only finer materials, some of which are held in suspension and some are moved along the bed. Since the carrying power of the stream depends upon its velocity, the maximum load would be carried where the current is strongest, and this would be at the

centre of the stream where friction is least. So it is only natural that when the river suffers a check at its confluence with the sea, a greater quantity of its load would drop off, in its bed, on the surface of the submerged platform. Only



Distributaries and Redistributaries from a Stream

a little of it, transportable by the feeble current still persisting, would be carried forward. This deposition, in its own bed, would be the greatest



at the centre, where more of the load was being carried than at the sides. Rainfall is not uniformly distributed in monsoonal regions and the rivers carry more water and necessarily a greater quantity of load during those months of the year when the monsoon blows. This is evinced conclusively from the fact that the water of all the rivers in Bengal is rather clear in the dry months, but becomes markedly turbid during the rains. This turbid water carrying the fertilising silt has been termed 'red water' by Sir William Wilcocks.

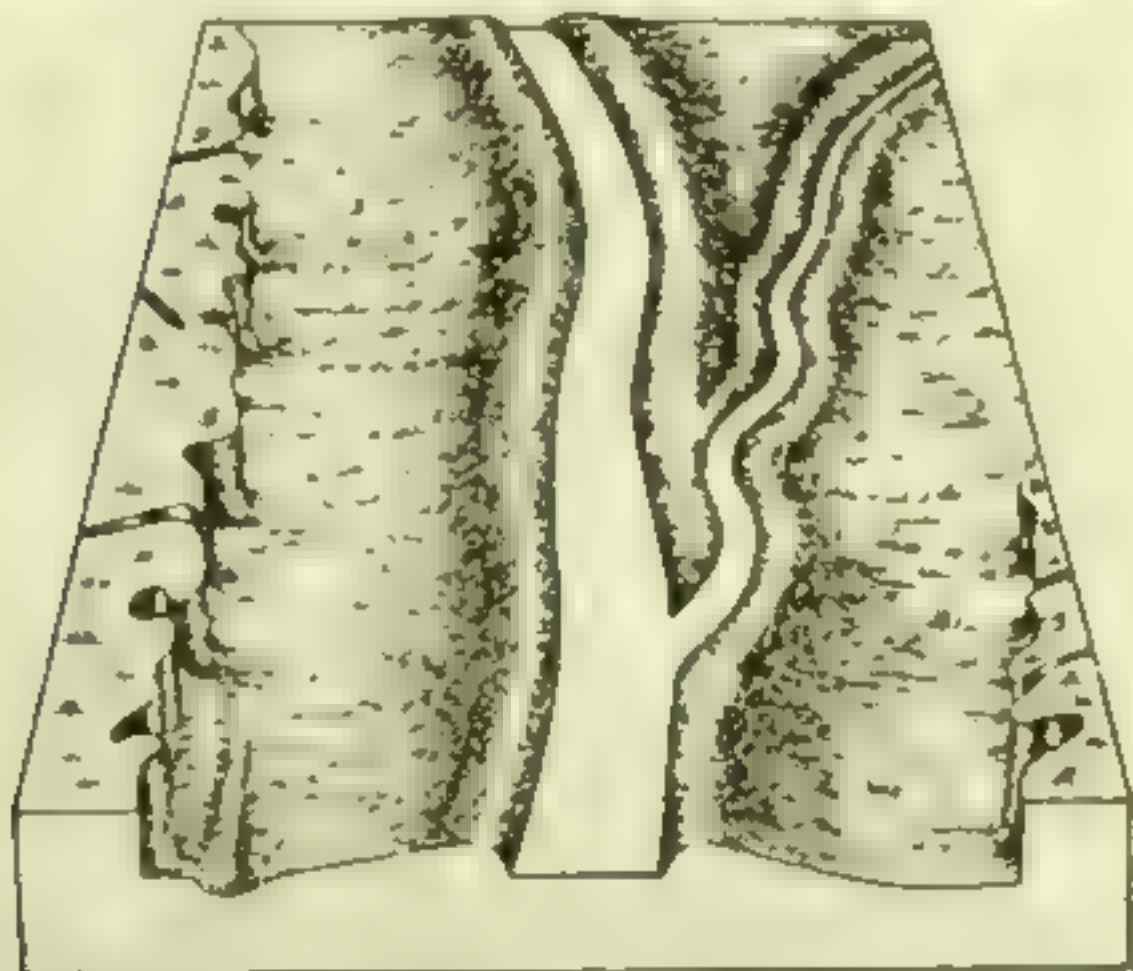
31. When the river is thus swollen, it deposits great quantities of material in its bed, which is not entirely washed away during the rest of the year when the stream has a much reduced volume and a feebler current. Successive monsoons add their quotas, till a mound develops in the bed of the stream at the confluence with the sea, which gradually becomes formidable enough to obstruct the direct flow of water across it. The stream, then, has to split at this point and flow by on either side. Thus is initiated the first two distributaries* at the furthest extremity, or what is known as the apex of the submerged platform, which is subsequently destined to become

* So called from the fact that they distribute the water of the main channel.

the delta. Exactly in the way in which the initial splitting gave rise to the first two distributaries, they, in their turn, due to the operation of the same processes, develop further split channels. These later-formed channels, from a consideration of their younger age and diminutive size, might be called *redistributaries*, as they again redistribute the water of the distributaries. As the distributaries develop only when a stream has attained considerable maturity and reached the deltaic phase, so also, when each individual distributary has gone through a similar life cycle, however short, and reached the deltaic stages in their own way, do they develop 'redistributaries,' the nomenclature that has been proposed in this book to designate these channels. Here, then, the distributary, with its system of redistributaries, bears the same relation as the main stream does to its system of distributaries.

32. A stream that was so long busy in building up a submerged platform, ultimately gives rise to a system of distributaries, which, again, go to form their own satellites of redistributaries. But the process does not end here. After the channels have been established and the banks consolidated in course of further inundations, when the flood overflows the banks in normal times and spreads out over the country, the largest amount of load is deposited on the banks themselves

where the depth of the water is most shallow, and the remaining quantity in the bed and the country around. This seasonal accretion to the banks and the bed of the stream gradually elevates the river to a position much above the country around. Such natural embankments, bordering



Levees and Shifting Channels

a river flowing at a level higher than the adjacent country, are known as *levees*, and these levees are invariable features of deltaic regions. This phenomenon of stream deposition in its bed and on the banks is, no doubt, primarily due

to the periodical inundations. But the tendency of depositing materials in its bed might also be derived from the lowering of the gradient of the stream itself from the elongation of the course over the deltaic tract.

33. When such levees are once formed, land building is, for the time being confined to the vicinity of these levees. But these natural levees are not uniformly strong all through their entire length, and whenever the pressure of water in the channels, during periods of high floods, becomes too great, or there is an undercutting, breaches are caused, through which escaping water flows out, making new channels over the adjacent country at a lower level. Thus new channels are formed, which may be termed *breach channels*, and these shifting channels, ramifying over the region, gradually raise the general level of the country to a height well above the flood level *. To this are added materials

* It will be interesting to quote here what Nevill observes from his experiment on delta building. "However the control of the delta shape by the continual migration and interlacing of the stream is very evident. Without guidance or direction, the initial stream soon builds natural levees, and this process continues until the stream is flowing in a channel considerably above the level of the delta plain. In this stage the stream is not in equilibrium with its surroundings, and a slight increase in volume or an undercutting will break the levee, the stream either dividing or entirely leaving its previous channel. By continually repeating this process, the stream controls and fashions the subaerial shape of the delta."

by subaerial erosion brought by wind and gravity from the country around, and the delta gains in height and consolidates. The contributions of the vegetational kingdom that bind the soil and add their own share of decompositional product are also no mean factors.

34 As the land comes to be consolidated, there is nothing to prevent the consolidation of the levees as well. The consequence of this is that the distributaries are no longer flushed by the run-off of the country around, which rather accumulates in the interim regions forming marshes. Not only this: their head portions, tending to rise higher and higher in comparison to the level of the parent stream, off take in these distributaries come to be gradually reduced and ultimately cut off by the deposition of sand in the head. Thus, as the distributaries begin to languish, death also gradually approaches the redistributaries, which come to depend ultimately upon the run-off of the neighbouring tracts for their flow. While this becomes the case in one part of the delta, the portion adjacent to it or lower below, where the general level is not yet so high, nor have levees been thrown out, comes to receive the major portion of the water of the main channel which is diverted through the creation of new distributaries and their system of redistributaries or by the enlargement of the already-existing smaller

Delta not a static region

ones into bigger channels. This lateral and forward accretion to delta dimensions is a dynamic growth to be found in case of most of the deltas. That portion of the delta where rivers are languishing and decay has set in, so to say, can be resuscitated through the activation of the distributaries and redistributaries. This happens naturally in two ways—either by a lowering of the level of the area through tectonics, when the channels will come to have an enhanced gradient, or by the rise of the sea level, when the active stage of the channels will gradually recede from the mouth sourceward.

35 Now that we have studied deltaic features, let us see how deltas may be distinguished from alluvial fans, with which they have many features in common. In both, the deposits are alluvial, and in both, the streams are constantly shifting and meandering in innumerable curves. But when once the origin of the alluvial fans is recounted, they become quite distinct from deltaic formations. Beginning from the river Kosi on the left, there are a number of mountain streams—the Mechi, the Mahananda, the Tista, the Jaldhaka, the Torsa, the Roydak, etc.—up to the river Brahmaputra on the east, all of which change their gradient as soon as they enter the plains of Bengal. In the upper reaches, it was possible for these streams to slide

Deltas and Alluvial Fans

downhill or transport downslope a huge quantity of load of variable sizes and proportions. But as soon as they enter the plains, the gradient reduces itself to a much gentler one, so much so, that the streams begin to meander. The huge load they carried so far, is dropped and piled up in the form of cones, with gentle angles of rest, ultimately spreading out, coalescing and distributing in the form of alluvial fans. The hydrographic nature of the tract of land between the Ganges and the Brahmaputra, and that between the Brahmaputra and the Meghna, indicate a gentle but uniform slope, from the head of the cones in the foot hills of the Himalayas and Assam hills, towards the south and south-east. But unlike the hypothetical radial slope of alluvial fans, in case of the above two, no slope towards the west is found because no stream large or small flows to the west. But this is a feature of all the rivers in Bengal, be it in the delta proper or in the alluvial fans. All the rivers, with the exception of one or two, have a south easterly course, and we shall see later on that the delta of the Ganges was also built up starting from the west gradually towards the east by throwing up new distributaries in that direction. Two factors might have played for this easterly trend of the rivers—either an initial eastward tilt of the

Eastward swing of
the rivers in Bengal

country due to tectonic disturbances (earthquakes?) or the influence of Ferrel's law (as suggested by A. K. Lobeck in case of rivers elsewhere). How far, really, the above factors have determined the easterly trend, and whether there are any other factors besides, it is not yet possible to reason out.

36. The shifting of the rivers in these alluvial fans is also of a different nature. When a river comes down in torrents in the monsoon months, it brings down quite heavy loads, which cannot be carried along as the water spreads out in the plains. Thus bar plains are thrown out and the rivers pass by them, taking up the appearance of braided channels. Water does not flow uniformly through every one of these channels, and according as the channels attain importance one after another, the main river is also found to shift.

37. Let us now sum up, in brief, the main points of divergence between
Monsoonal character predominates
Points of divergence deltas and alluvial fans:—

(a) A delta is a subaqueous formation, where the strata are arranged in particular fashions—bottom-set, fore set and top-set beds. Alluvial fans are subaerial deposits where a crude sort of stratification may develop, but the deltaic structure is not to be found.

(b) A delta terminates with a steep slope towards the sea, whereas alluvial fans merge gradually outwards into the adjacent country.

(c) Braided channels and shifting of rivers might be found in both, but they are due to different causes generally. Levees may also be formed in alluvial fans.

(d) The nature of channels in the case of deltas is exclusively in the form of distributaries and redistributaries, whereas that in the case of alluvial fans is in the form of tributaries generally.

38. The above deltaic features are restricted in Bengal to the tract of the Delta of the Ganges the only delta in Bengal. country south of the Ganges (Padma), between the Bhagirathi on the west and the Meghna (combined waters of the Ganges and the Meghna river) on the east*. So that this portion is the only deltaic region in Bengal. Be it noted also that the Ganges delta is also designated as the delta of the Ganges Brahmaputra (see Fox, Geikie, Lobeck, etc.) There is absolutely no doubt that the Brahmaputra is a mighty tributary of the Ganges, meeting it at Goalundo, and contributes a considerable portion of the

* If any portion of the alluvial fan to the north were once deltaic (which can only be revealed through the presence of deltaic structures underground), it cannot on the ground of its palaeogeography, be now included within the present limits of the delta. There is no longer any deltaic feature on the surface to warrant such inclusion.

material with which to build up the delta. But such contributions also come, though in lesser proportions, from the tributary Meghna, meeting the Ganges (Padma) at Chandpur in the east and the Damodar, the Rupnarayan and other tributaries in the west. They have equal claim, then, to associate their names too, if that of the Brahmaputra be so associated. If we look up all the other deltas of the globe, in none of them have the tributaries been given this consideration, nor has it been thought necessary. So, I propose to call the deltaic region in Bengal the *Delta of the Ganges*, and I would like to suggest that the name "Ganges Brahmaputra Delta" or "Bengal Delta" should no longer be used.

39 A consideration of all the views, then, leads to the following conclusions :

Neither the western part of Bengal to the west of the river Bhagirathi nor the south-easternmost part to the east of the river Meghna can be included within the Deltaic region. The region between the Brahmaputra and the Meghna has also to be left out. The area between the Bhagirathi and the Meghna (i.e., the combined waters of the Ganges and the Meghna) is the only region bounded by the distributaries of a river, where physiographic and hydrographic characters constituting a delta are distinctly observable. This is also the area, beyond dispute, of

The present Deltaic Region



transcendent deposition. The edge of the delta forms a steep drop as it terminates into the Bay of Bengal.

40. In the present work, therefore, the roughly triangular tract of land resembling the Greek letter Δ , commencing from Gaur, the point whence the first distributary of the Ganges comes out, extending up to the Bay of Bengal, and bounded on either side by the Bhagirathi and the Meghna (after it combines with the Padma), has been included within the deltaic region.

The following districts or portions of them fall within this region :—

- (1) Murshidabad (only the portion east of the Bhagirathi).
- (2) Nadia.
- (3) Jessore.
- (4) Faridpur.
- (5) 24-Parganas.
- (6) Khulna.
- (7) Bakarganj.
- (8) Noakhali (islands only).

41. Of these, Murshidabad, Nadia, Jessore, 24-Parganas and Khulna are situated within the Presidency Division, Faridpur and Bakarganj in the Dacca Division, and Noakhali islands in the Chittagong Division. The reasons why the

western part of Murshidabad, beyond the Bhagirathi, has been excluded are twofold: (i) it partakes of the nature of tableland,* (ii) this part is not included within the westernmost distributary, the Bhagirathi, and so does not come within the definition of the term delta. The mainland portion of the Noakhali district, also, does not come within the easternmost distributary of the Ganges and, moreover, the degradation of the land is at present more active in the Noakhali mainland than aggradation.†

42. The apex of the triangle comprising this delta is at a latitude of 24° 40' N, longitude 88° E and the southern extremity stretches as far down as 21° 30' N latitude. The longitudinal extension of the base of the delta is from 88° E longitude to 91° 50' E longitude. The area covers roughly 63,809 sq. miles, i.e., a little over one-fourth of Bengal.

* Report of the Drainage Commission, 1907, Census Report, 1921, Vol. V, Final Report of Settlement and Survey Operations in Bengal—Murshidabad District.

† Census Report, 1921, Vol. V.

CHAPTER IV

FORMATION OF THE GANGES DELTA

43. The entire deltaic region of Bengal was once under the ocean, and the Ganges used to meet the sea at the apex, or a little upwards, in the neighbourhood of Gaur. To start with, it might have met the sea in one unsplit stream, but debris began to accumulate at the confluence and the river commenced giving off distributaries. The westernmost distributary of the Ganges, and one to form the boundary of the delta on that side, is the Bhagirathi, the easternmost being the Padma. Divergent views are held on the question as to which one of these two was thrown off first and at what point of time.

44. Wilcocks, for one, suggests, from his interpretation of the story of *Bhagirath*, that the distributary Bhagirathi is nothing but an excavated channel (credit for the achievement being due to the engineer Bhagirath), to bring down part of the water of the Ganges, the whole of which used to escape through the Padma. He clearly means, by this, that the Padma was formed first, from which the Bhagirathi was excavated later.

Was Bhagirathi a
canal?

45. Hydrographically considered, this probability of the Padma channel being formed first and the Bhagirathi afterwards, would seem rather unlikely.

Bhagirathi formed the Main channel prior to spitting

The swift flowing waters of the Ganges, coming with sufficient force through the plains of the U. P. and Bihar, take quite a sharp bend to the south after rounding the Rajmahal hills. The dash of the current below this point would tend to follow a straight course onward, a course which can only be deflected if obstacles appear in its way further downstream. But the Ganges, coming to Bengal, has arrived in a country having little or no relief and offering very feeble resistance to the action of river-scouring, the soil being loose and soft. It does not seem likely, then, that there would be sufficient obstacles in the path of the strong current to proceed along its normal course, and the Bhagirathi would thus appear to be its original course to the sea, skirting the edges of the plateau to the west. This is also the shortest route to the Bay.

46. It is held by many* that the rivers of North Bengal—the Mahananda and others—used to meet the sea flowing longitudinally from the Himalayas to the Bay, and that the Ganges

* Vide Bengal District Gazetteers—Murshidabad

beheaded them subsequently by its eastern swing. If the Ganges, then, had to meet the Bay without beheading the Mahananda, etc., at any period, it must have done so through the Bhagirathi and not the Padma.

47. The historians and antiquarians also support the proposition that the Bhagirathi is the older of the two channels. The earliest record available, in which the names of the distributaries of the Ganges appear, is the *Matsya Purana*. "The Purana designates all the streams rising from the Himalayas by the common appellation of the Ganges and actually names seven of them. The middle stream is distinguished by the name of Bhagirathi, which is declared to have descended to the earth through the devoted labours of Bhagiratha. . . . It is distinctly stated that the Ganges fell into the southern sea past the countries of the Kurus, the Bharatas, the Panchalas, the Kausikas, the Magadhas, the Brahmuttaras, the Vangas and the Tamraliptas, after having dashed against the Vindhya hills, i.e., hills of Rajmahal (*Matsya*, Ch. 121). The first three countries are included in the United Provinces of modern days. The next two represent northern and southern Bihar. The last three represent Bengal. It is clear, from this record of the Ganges flowing past Tamralipta or modern Tamruk, that the western-

most branch, i.e., the Bhagirathi or the Hooghly, is meant, and that it was once recognised as the real Ganges. Mention of the Vangas would show that the eastern courses were also probably known; but in the absence of the mention of a definite landmark like Tamralipta, it is not possible to lay stress on the point.

48. "In the *Ramayana*, the story of the bringing down of the Ganges from the celestial heights by King Bhagiratha is given in great detail. Unfortunately, no topographical details are given, and the Ganges goes straight to the ocean at Gangasagar, south of modern Calcutta. This account also has, therefore, the Bhagirathi course in view as the main course of the Ganges.

49. "In the *Mahabharata*, in the *Vana-parvan*, Yudhishthira, in the course of his pilgrimage in eastern India, came to the mouth of the Ganges (Gangasagar) and bathed there 'in five hundred rivers,' and then went towards Kalunga by the sea shore. Here also the Gangasagar or the Bhagirathi course appears to have been the principal course, though the numerous mouths of the Ganges appear also to have been known."

50. Mr. O'Malley (*Bengal District Gazetteers - 21 Parganas*, Ed. 1914) is of opinion, that "The present channel of the Hooghly is very different from that which the Ganges formerly followed. The original channel was identical with

At ganga the original course of the Ganges

Tolly's Nullah from Kidderpore to Garia (8 miles south of Calcutta), from which point it ran to the sea in a south east direction. It is still traceable as far south as the Jaynagar thana."

W. H. Carey (*Good Old Days of Hon'ble John Company*, Vol II, p. 157) also makes the statement that "It is supposed that the Ganges once flowed on the site of the Tolly's Nullah. On its banks is the Kalighat Temple.

51. "There is epigraphic evidence to show that the present course of the Bhagirathi south of Calcutta (now Uluberia and Gangasagar) has remained unchanged at least from about 1025 A.D. If ever the Bhagirathi flowed by Tolly's Nullah, i.e., the Adiganga course, it must have done so previous to this date. The age of the Adiganga course can be surmised from this fact. It will appear subsequently that the present mouth of the Hooghly existed in the days of Ptolemy (150 A.D.) and he calls it the Kambyson mouth. The next mouth is called the Mega, or the Great Mouth, 1°15' to the east. The qualification 'Great' attached to the mouth is significant and is only justified by the assumption that the Adiganga and other rivers then flowed into it. This would also give us an inkling into the age of the Adiganga course

52. "If the Bhagirathi course had begun silting up even in prehistoric days and required



gigantic dredging operations about 2000 B.C. to be kept navigable, when were the courses further east born? When were the Padma and the intervening courses born? It is easy to trace the course back by about two thousand years.

53. " Though references to different channels of the Ganges are to be found in Hindu and Muhammadan accounts, proofs for the existence of a number of mouths of the Ganges and an easternmost and a westernmost course become abundant in the writing of the Greek and Egyptian writers in the early centuries B.C. and A.D.

54. " These Greek and Egyptian accounts are particularly valuable, because there is nothing in the contemporary literature of our own country that can approach them in the fulness and accuracy of the information furnished.

" Let us begin with the latest of these authors, viz., Ptolemy, who wrote his famous geography about 150 A.D. He gives the fullest account of the Lower Ganges, its mouths and the country which they traverse. Below we quote the relevant passage* :

Ptolemy's evidence

Mouths of the Ganges : -

The Kambyson mouth, the most western—
Long. 144° 30', Lat. 18° 15' ;

* N. K. Bhattacharya: *Antiquity of the Lower Ganges and its Courses*, Science and Culture, Nov., 1941

Poloura, a town— 145° , $18^{\circ}30'$;

The second mouth, called Mega— $145^{\circ}45'$, $18^{\circ}30'$;

The third mouth, called Kamberikhon— $146^{\circ}30'$, $18^{\circ}40'$;

Tilogrammon, a town— $147^{\circ}20'$, 18° ;

The fourth mouth, called Pseudostomon— $147^{\circ}40'$;

The fifth mouth, called Antibole— $148^{\circ}30'$, $18^{\circ}15'$.

"It will be seen from the above passage that Ptolemy is very definite about the five mouths and their location. He places them between the longitudes $144^{\circ}30'$ and $148^{\circ}30'$, i.e., within four degrees. . . .

"In actual measurement, Ptolemy is found to have erred by about 16 minutes, and allowing a correction of 4 minutes to a degree, for the four degrees, we should have no hesitation in locating the five mouths of the Ganges, as mentioned by Ptolemy, as follows:

(1) Kambyson mouth (longitude $144^{\circ}30'$) is the Sagar Island mouth of the Bhagirathi in the longitude of Tamruk (mentioned by Ptolemy as Tamalites or Tamralipta, $144^{\circ}30'$).

(2) The Mega or the Great mouth (longitude $145^{\circ}45'$) is located by measurement in the Ramangal or the Hariabhanga channels. This appears to have been the outlet for the Adiganga channel flowing by Kalighat in Calcutta (Tolly's



Nullah) in which Ganges is traditionally believed to have flowed in very early days. From its name Mega or the Great, it appears to have been of greater importance in Ptolemy's days than the Kambyson mouth. The Matia channel, about half a degree westward, is ignored by Ptolemy.

(3) The Kamberikbon mouth (146° 30') is located by measurement in the wide Haringhata channel, in the upper reaches of which we meet with the feeder river Kumara which still exists.

(4) The fourth mouth, called the Pseudostomon or the False mouth (147° 40'), is located by measurement as the Shahbazpur channel between the islands of Hatia and Dakhin Shahbazpur. It should be observed that Ptolemy passes over the Tetulia channel, about half a degree to the west, between the mainland and Dakhin Shahbazpur. In his days, therefore, it was not as prominent as is shown on modern maps. The Shahbazpur channel, passing through shoals and sandbanks, is indeed a false mouth.

(5) The fifth mouth, Antibole (148° 30'), is located by measurement in the Sandwip channel between Sandwip and Chittagong coast.

55. "The almost perfect agreement between the longitudes of the mouths of the Ganges as marked by Ptolemy and their longitudes as is to be found on modern maps, and the incontrovertible identity of the present Sagar Island mouth of the modern maps with westernmost

Kambyson mouth of Ptolemy's records, leave little doubt about the existence of an easternmost mouth also in the days of Ptolemy to be identified with the united waters of the Ganges and the Brahmaputra between the Sandwip Island and the Chittagong Coast.

56 " Ptolemy's easternmost course or Antibole would appear to have been the principal course of the Ganges in his days, as the *Periplus of the Erythrean Sea* (Schoff's edition, Intro., page 16), compiled about 60 A D. by an unknown author, knows of no other course "

Megasthenes says, . . . Ganges—Now this river empties its waters into the ocean forming the eastern boundary of the Gangaridae. . . The final part of its course is through the country of the Gangaridae.

From these passages, it will be evident that Megasthenes in 300 B.C. also knew the easternmost course as the principal course of the Ganges.

But Ptolemy's account written about 450 years after Megasthenes mentions Adiganga mouth as the Great mouth, probably implying that Adiganga or the Bhagirathi was the principal course.

57. " The superior sanctity of the Bhagirathi course is sung in all Sanskrit authorities and is recognised up to the present time. If my interpretation of the Bhagirathi story* is accepted,

* A commonsense interpretation of the Bhagirathi story is that this mouth of the Ganges had become silted up even in the days of

it would serve to show that this, the earliest course, went moribund even in prehistoric times and had to be kept open artificially. The fact that Megasthenes and Periplus recognised the easternmost course as the Ganges would show that even in 300 B.C. the Padma course was the principal course of the Ganges and the Bhagirathi had become comparatively unimportant, though originating earlier and superior in sanctity. The Padma course must have originated later than the Bhagirathi course, but when, it is impossible to tell. But of this we are sure that the birth of the Padma took place before 300 B.C., and during the historic period from 300 B.C. up to the present day, it has uninterruptedly been the principal course of the Ganges.”*

58. Several things become clear from the above quotations :

The Bhagirathi channel, which was the oldest course, was the earliest to attain prominence, and it began silting up as early as 2,000 years back. The Ganges Delta was completed, much as its present configuration, at the time when Ptolemy prepared his map, i.e., 150 A.D., so that it is at least 2,000 years old. The Padma was later to

Bhagiratha (approximately 2000 B.C.), and it was through the gigantic labours of that monarch that this course was given a fresh lease of life. (This footnote is Bhatnagar's.)

* Vide N. K. Bhatnagar's paper already referred to (p. 44)

attain its present importance, evidently at the expense of the Bhagirathi, which fact indicates that the delta, being formed in its embryonic form near the apex, gradually extended eastwards and southwards.

CHAPTER V

STAGES IN THE FORMATION OF THE
GANGES DELTA

59. As to the way in which the deltaic region of the Ganges has been gradually built up, it will be instructive to recall what Dr. Thomas Oldham has said in the *Proceedings of the Asiatic Society of Bengal*, 1870, p. 47 :—

Oldham's view

“ The Ganges river, emerging from its upper levels round the Rajmahal Hills and prevented by their solid rocky barrier from cutting further to the west, sought its channel in the lower ground adjoining, and originally the main body of its waters flowed along the general course now indicated by the Bhagirathi and Hooghly. But gradually filling up this channel, it was again compelled to seek a new course in the lower—because as yet comparatively unfilled in ground lying to the east. And the same process being repeated, it wandered successively from the rocky western limit of the delta flat towards the eastern. If this progress eastwards was allowed to be sufficiently slow to admit of the gradual filling-in of the country adjoining, the delta was formed continuously up to the

same general level, and the larger streams or channels passing through this flat to the sea became unavoidably diminished in size, and in the quantity and force of the water they carried, the main body passing around further to the east and having its course in the channels successively formed there . . . "

60. It has been mentioned already that, in the deltaic stage, the rivers do not—in fact they cannot—continue to flow in the same channel for a great length of time.

Successive stages
in the formation of
the Delta.

" Every stream, whether large or small, flowing through such a flat, tends to raise its own bed or channel by the deposition of the silt and sand it holds suspended in its waters, and by this gradual deposition the channel bed of the stream is raised above the actual level of the adjoining flats. It is impossible to suppose a river continuing to flow along the top of a raised bank, if not compelled to do so by artificial means, and the consequence of this filling-in and raising of its bed is that, at the first opportunity, the stream necessarily abandons its original course, and seeks a new channel in the lower ground adjoining, until after successive changes it has gradually wandered over the whole flat and raised the entire surface to the same general level. The same process is then repeated, new channels are cut out, and new deposits formed."

61. This is exactly the process responsible for the throwing up of the successive distributaries by the Ganges, beginning with the Bhagirathi. When the Bhagirathi completed raising its bed sufficiently high above the surrounding tract and lowered its own gradient quite considerably, the accumulated waters of the Ganges began assuming a rather easterly trend and the next great distributary to develop eastwards was the Bhairab, which then served as the main outlet for the waters of the Ganges. There is also another view as to how the Bhairab has come into being, "... it seems clear that at one time the Ganges found its way to the sea along the course of the Bhagirathi, and in those days, before the Padma broke its way eastward and intersected the drainage of the Darjeeling Himalayas, there must have been some earlier streams to carry that drainage to the sea, of which the Bhairab is said to have been one. Now-a-days, however, all the drainage of Northern Bengal is intercepted by the Padma before it reaches Nadia. . . . (*Bengal Dist Gaz — Nadia Dist*, p. 4) According to this view, then, the Bhairab has been turned into a distributary, subsequent to its upper part (which is likely to be the Mahananda) being captured by the Padma. The Bhairab has now ceased to be the mighty river it once was, and its entire course has been dissected

into three parts by the streams Jalangi and Mathabhanga. But prior to its decay the Bhairab maintained a mighty channel from the Padma off-take opposite Rampur Boalia right up to its discharge in Haringhata estuary. The intervening tract between the Bhagirathi and the Bhairab was gradually raised up by the alluvium thrown by the two distributaries and the intervening redistributaries, the Jamuna, Churni, Ichamati, Betna, Kobodak, Bhadra, Rupsa, etc., over the entire area flushed by them. For convenience they might be designated as the Bhairab system of distributaries. As this region was elevated higher and higher, the rivers developed elevated beds, with decreased gradient, and the Ganges migrated further eastwards for an egress in the form of the Mathabhanga.

62. The next distributary, then, to attain prominence is the Mathabhanga, Mathabhanga system whose off take is about ten miles below the point where the Jalangi diverges from it. The first redistributary to be thrown off the Mathabhanga is the Kumar*; further south there are the Nabaganga and the Chitra. The course of the Mathabhanga then usurped the

* According to Mr. S. C. Majumdar, late Chief Engineer with the Govt. of Bengal, the Kumar appears to be an older channel than the Mathabhanga, which formed subsequently on the death of the Bhairab, absorbing the upper portion of the Kumar and the portion of the Bhairab lower down.



channel of the Bhairab from below Sukalpur to Sultanpur and, proceeding further south, transmitted its waters into the Churni and the Ichamati. The beheaded Bhairab henceforward becomes an insignificant stream. It is difficult now at this present state, when all the distributaries have been adversely affected and are almost equally getting less and less active, to decipher which of the distributaries formed the continuation of the Mathabhanga main channel, down which a greater portion of the Ganges water rushed to the Bay.

63. The Mathabhanga, along with her system of redistributaries, namely, the Kumar, Nabaganga, Chitra, etc., helped by those of the headwaters of the Bhairab, extended the deltaic region and raised the general level eastwards up to the furthest end of Faridpur at least up to the border of the Arniakhan.

64. Unlike the other distributaries such as the Bhairab or the Mathabhanga, the Garai did not attain any importance in earlier times. It flowed then only as a cross channel between the Ganges and the Kumar.* Regarding

Garai not an important distributary in former times.

* The development of the Garai, in the opinion of Mr. S. C. Majumdar, "was due to the diversion of the Brahmaputra through the Jamuna channel meeting the Ganges at Goalundo, thereby heading up the Ganges flood to a certain extent and forcing it to find some other outlet higher up."

the condition of the Garai, O'Malley writes, "At the point where the Garai now receives the Kumar, the Kumar then received the Garai, which at that time was but a cross stream from the Ganges. A little further down the old Kumar sent off a channel, the Barasia, which flowed southwards, while the Kumar continued its eastern course towards the Ganges beyond Faridpur. When the head of the Kumar began to silt up, the Ganges poured more and more of its waters down the Garai, which then began to swallow up the Kumar. The Garai, thus reinforced, continued its course down the Barasia, and the latter, which had hitherto been but a narrow river, proved unable to carry off this influx of water, and opened out a new western channel called the Alangkhal. These two, viz., the Barasia and the Alangkhal, united in a great marsh, which occupied the site of Mukimpur Pargana and formed that wide stream above the confluence, to which the name of Madhumati was extended."

65. O'Malley throws further light as regards the recency of the Garai when he says, "The inundations which occurred about Muhamadpur in the early part of the 19th century were clearly connected with changes then going on. After a few seasons of disastrous floods, an adequate channel gradually formed and the new

Garai • recent
river

stream flowed more regularly; inundations on the terrible scale common a century ago have long since ceased. This comparatively recent opening of the Madhumati channel also explains how, while the courses of *old* rivers (*viz.*, the Kumar, Bhairab, Bhadra and Kabadak) are the boundaries of old Parganas, the *new* rivers (*viz.*, the Garai and Madhumati) flow almost throughout their whole course through the heart of successive parganas, such as Nalch, Nasratshahi, Sator, Mukimpur, Sultanpur, Salimabad, etc."

66. There are indications, on the other hand, that as late as 1820 five-sixths of the water of the Mathabhanga made its way down the Kumar. "During the end of the last century the river," writes O'Malley, "has been described as a beautiful stream of clear water navigable by large vessels all the year round." In its lower reaches, it used to receive water from the Garai through the Kalganga, but this connection has also silted up. It still, however, carries off the flood discharge of the Mathabhanga during the rains."

67. It seems likely, then, that a considerable portion of the Mathabhanga system of delta was built up by the Kumar, and when the delta became mature like its predecessor, the Bhairab

Kumar, an important distributor to Mathabhanga system of Delta.



system, the Arialkhan mouth developed. It may be that the Garai was in existence prior to the development of the Arialkhan channel, but it was only a very small channel then, playing little part in deltaic formation.

68. If O'Malley's assumption, that the Garai-Madhumati channel became
Arialkhan attains importance important after the series of disastrous floods in the early part of the 19th century, is taken as representing the true state of affairs, and Bhattasali's view of placing the age of the Arialkhan as a mighty river at least near about 1624 A.D. be accepted, then the portion of the delta now represented by eastern Faridpur and the islands to the south-east have developed by the deposition made by the Arialkhan and her system of redistributaries. The Meghna does not seem to have made any substantial contribution, because of the fact that its fast current does not allow much of the debris dropped at the mouth to accumulate. This receives further support from the statement made that the seaward extent of land in the district of Noakhali is said to have been washed away to a much greater extent than what has been added to it by way of deposition. The Garai-Madhumati channel, of which mention has already been made, is now engaged in raising up the deltaic portion built up by the Arialkhan system.

69. The development of successive stages in the building up of the upper portion of the delta by the gradual appearance of the different distributaries like the Bhairab, Mathabhanga, Arialkhan, etc., with all of their systems of redistributaries as enumerated above, is not meant to convey the impression that the events took place in time and space in the order described. There is absolutely no ground to maintain that, when the Bhairab was an active stream doing its function of delta building, both in extent and in volume, the Mathabhanga channel was not there. It is equally unsound to conclude that Arialkhan was not there when Mathabhanga-Kumar were in their prime. What is intended to be emphasized is that all the different distributaries were not equally active simultaneously to contribute to the delta formation. When the distributaries in the west were active, those in the east were perhaps in their infancy, and as the rivers to the east were adolescent, those in the west became senile. The active stage of delta formation thus migrated south-eastwards in time and space, leaving the rivers in the old delta, now represented by Murshidabad, Nadia and Jessore with the Goalundo Sub Division of Faridpur, to languish or decay.

70. Such stages in the formation of deltas are also noticed in case of the delta of the St. Clair. It has two parts, the old delta on the eastern portion and the new delta on the western portion. According to Lobeck, each of these represents a period of active delta building. After the old delta was built, the upper Greek lakes discharged, by way of Georgian Bay through the Trent River outlet, into the St. Lawrence, and very little water flowed through the St. Clair River. With the uplift of the region to the north the lakes have again renewed their former course of discharge and the present bird's foot type of delta is being actively formed (*Geomorphology*, p. 233).

71. The entire deltaic region, then, can be divided, depending on the state of maturity attained, into three parts, Moribund, Mature and Active Delta. The condition of the rivers provides a key to this. The part characterised by dead rivers—dead in the sense that they have lost connection with the main channels and have no longer any off-take now—may be considered as 'moribund delta.' No silt is added to the region now and active land formation has ceased. The portion where rivers are active yet, but have just ceased carrying silt and maintaining their function of active land formation may be termed 'mature delta.' The land has

attained maturity but decay has not yet set in. The third subdivision, namely, 'active delta,' is characterised by active streams carrying silt, where land building is still proceeding in full swing.

72. As regards the development of the cross-channels or dead rivers in the upper part of the delta, *i.e.*, in the districts of Murshidabad, Nadia and Jessore, there are different views. One school, for example, represented by Willcocks, holds them as artificial canals, excavated for irrigation purposes, from consideration of the following facts, among others :—

(1) The spacing apart of the canals (*i.e.*, drying rivers) is just where canals would be placed today if there were none already on the ground.

(2) They are fairly parallel and continuous in the direction in which they start, which is absolutely artificial.

(3) They are wide and shallow to carry the beneficial muddy surface waters of the rivers and avoid the harmful sandy waters of the beds.

(4) The villages are constructed on their banks, as villages would naturally be constructed, under the conditions in Bengal, on raised banks.

(5) All the canals were originally dug straight as a matter of course, but their winding courses today are a true gauge of the friability of the soil they traverse. Their winding courses along

their original alignments are nature's masterful handiwork.

73. It is the view held by one section of engineers that the evidence on which Willcocks bases his arguments are insufficient. Referring to the lectures delivered by Sir William Willcocks in March, 1928, and the articles contributed by him in the public press, the report of the Irrigation Department Committee, 1930, makes the observation that "In these he advanced a theory of his own as to the nature of the various effluents of the Ganges and took the Department to task for not having devoted their energies to the restoration of the ancient artificial systems of irrigation, which, according to this theory, existed in Bengal in the past. . . . We have found nothing in the facts adduced by Sir W. Willcocks in his lectures which we should be prepared to accept as even reasonably convincing evidence in support of his theory of the origin of the Nadia rivers and of the existence in the past in Bengal of artificial systems of irrigation, such as he describes. Many of the conclusions at which he has arrived appear to those of us who are engineers to be based largely upon incorrect premises and insufficient data; they are certainly not such as can be blindly accepted in the way which he advocates" (p. 7). Evidently they maintain that these streams are of natural



development* and that their decline has come as a normal sequence of events in a deltaic country. Whatever might be the origin, there is no doubt in the fact that these channels at one time took a considerable part in building up the delta both in volume and in extent and the country became sufficiently stable.

74. All lands to the north of a line joining Calcutta and Khulna proceeding due east up to the Madhumati, bounded on the west by the Bhagirathi and on the east by the Madhumati, is characterised by rivers that are all in their decaying phase. These have lost connection with their parent streams. The districts of Murshidabad (eastern half), Nadia, Jessore and portions of the 24-Parganas and Khulna come within this region. This is the portion designated as the Moribund Delta. The higher parts are those forming the banks of these rivers, thick with villages, and the interriverine tracts are marshes or portions with inland drainage. The rivers having now no off take from the main

* Mr. S. C. Majumdar suggests that the development of these cross channels is probably attributable to the funnel shape of the Bay of Bengal and the existence of the swatch of no ground in the middle. For the above reason and also due to irregular extension of the delta, the tides do not occur absolutely at the same time at different points in the same latitude along the delta face, thus giving rise to cross currents between the deeper channels just below the outfalls of contiguous north to south delta boulders (*Rivers of Bengal Delta*, pp. 118-19).

streams cannot bring down enough water and silt, even in flood, and being confined within high levees, are not in a position to inundate the entire country. As a result, land building has ceased and the delta has grown moribund up to this limit.

75. As soon as we come to the south of the
 Mature Delta line, we arrive at a strip of country stretching up to the Sunderban forests, where the rivers, though continuations of dead channels from above, have remained flowing from the run-off of the adjacent country. But though the streams have remained flowing, all of them cannot add to the elevation of land, because their head portions supply no silt to them. It is only in the vicinity of a river that still carries enough silt from upper regions, that lands are being raised. Such areas are bordering the river Hooghly and the Meghna. The tract between the Bidyadhari (which subsequently flows into the Matla) and the Rupsa or Pussur was built up and raised to the present height when these and the intervening rivers, Jamuna, Kabodak, Bhadra, Bhairab, etc., were active and carried huge quantities of silt inundating the entire landscape, as is now done by the Garai, the Arsal-khan and the Meghna.

Regarding the condition of rivers between the Jamuna and the Madhumati in Khulna, O'Malley writes :—

"The main rivers entering the district from the north, from the Jamuna on the west to the

Madhumati on the east, are offshoots of the Ganges, by which they were originally fed; owing, however, to the elevation of their beds in their upper reaches, the current of the Ganges is deserting them, and is being deflected further and further to the east. The Madhumati alone continues to bring down any great quantity of the Ganges water to the sea, and the other main rivers serve chiefly as lines of drainage to carry off the local surface water. They were at one time great waterways with a good depth of water even in the dry season, and during the rains carried down a large volume of flood water. But, one by one, their heads have closed up and their lower reaches have consequently deteriorated. Even as late as 20 and 30 years ago (about 1893) the principal rivers still conveyed fresh water through the district until they entered the Sunderbans; but now there is scarcely a river that does not become brackish in the dry season, and saline water forces its way far inland."*

76 The result is that only in parts of the district the land is being elevated by the deposit of the river silt carried in suspension in flood water, viz., to the east, where the Ganges water finds an outlet by the Madhumati and other channels. Elsewhere this process of land raising is in suspension, as the water courses now receive

* *Bengal District Gazetteers—Khulna*, p. 8.

no flood water from the Ganges, and their channels are far too large for their function as receptacles of the local drainage. Thus, then, is the region of Mature Delta.

77. The result has been that in this strip and also in the zone of the Depressed zone in the middle Sunderbans, presently to be studied, the western tract between the Hooghly and the Bidyadhari and the eastern tract between the Madhumati and the Meghna is gradually being raised, whereas the middle portion, being deprived of the annual deposition of silt, is getting more and more depressed comparatively.

78. That the strip of land presently described Evidence of marshes has ceased to be in active phase of land building, and has been deprived of the silt from the rivers flowing through, gets support in another very convincing physical evidence, namely, the great chain of brackish marshes stretching from the vicinity of Calcutta and extending eastwards to the neighbourhood of Barisal. This line of marshes, suggests Mr. S. C. Majumdar, "more or less defines the boundary between the upper delta built up by the upland silt which action has now practically ceased and the lower delta where land building actively is going on to a certain extent by the tidal channels which are still carrying a large quantity of silt."

79. Coming immediately to the south of the area just dealt with, there is a strip of land designated as the Sunderbans; at one time its extent was "the southernmost portion of the Gangetic delta situated between $21^{\circ}31'$ and $22^{\circ}38'N$ and between $88^{\circ}5'$ and $90^{\circ}28'E$, extending over an area of 6,520 sq. m., of which 2,688 sq. m. lie in Khulna, 2,941 sq. m., in the 24 Parganas and 897 sq. m. in Bakarganj" (*Bakarganj District Gaz.*).

"The tract is bounded on the north by the permanently settled lands of the 24-Parganas, Khulna and Bakarganj; on the east and west respectively by the estuaries of the Meghna and the Hooghly; and on the south by the Bay of Bengal. It has a length of 170 m. along the sea face and stretches inland for a distance of from 60 to 80 miles."

The northern border of the Sunderbans now, however, has been cleared up to some extent by gradually extending cultivation from the north and the migration of land building action southwards, and its present northern extent can be put as a line extending from Kulpi on the Hooghly to Kaliganj on the Jamuna, thence from Pirojpur on Baleswar up to Patuakhali on the Ariakhan.

80. The region has thus been described in the *Bengal District Gazetteers—Khulna District*, by O'Malley, "Briefly the Sunderbans may be

described as a low flat alluvial plain in which the process of land making is still going on, covered, where not under cultivation, with forests and swamps, intersected from north to south by wide tidal rivers or estuaries, and from west to east by narrow tidal rivers or creeks. All the estuaries, and most of the rivers, are salt; there is little or no current down them, and they are practically tidal water courses. They are connected with each other by an intricate series of branches, and the latter in their turn by innumerable channels; so that the whole tract is a tangled network of estuaries, rivers and water courses, which enclose a large number of islands of various shapes and sizes. These flat swampy islands are covered with dense forests, the most plentiful and important species being Sundri (*Heritiere littoralis*), which thrives most where the water in the channels is least brackish.

81. "Along the sea face the forest is almost composed of mangroves, which sometimes extend into tidal water, but elsewhere are separated from the sea by a line of low sand hills or dunes." Even in this region, as already mentioned, the areas can be divided into two comparatively higher ridges bordering on the Hooghly and the Meghna and a depressed zone in the middle, which, according to some, was once a marsh, as depicted in the map of Rennell between the

years 1764 and 1772. These marshes, if there were any, have now disappeared, however, though the area continues to be a low one. The most notable feature about this network of islands is that the land is hardly above high tide level and far from becoming a firm land. The soil is yet immature and the water everywhere is rather saline. Virgin forests cover this region except where man has tried to stamp his mark on it. This, together with the district of Bakarganj and the islands of Noakhali district form what has been called as the Active Delta.

Regarding Bakarganj Jack says (*Bengal Dist. Gaz.—Bakarganj*, p. 2). "It appears probable, however, that it consisted of a chain of islands separated by wide rivers in the thirteenth century. These have gradually consolidated into the modern district and the process is still going on in the large area which is covered by the waters of the Meghna. The deposit has been the work of three rivers, the Padma, the Brahmaputra and the Meghna, but it seems that the Brahmaputra, which to this day carries far more silt than the other rivers, had the chief work in filling up this part of the delta."

82. It has already been mentioned, that O'Malley described the area of Sunderbans as a region in which "the process of land making is still going on." If the map of

Is the Delta
advancing?

the delta in Bengal, as surveyed and drawn by Rennell in the year 1770, be compared with the map prepared by the Survey of India in the year 1906, the extent of the deltaic region southwards in both the cases would be 21°31' N latitude.

This leads one to infer that there has been no appreciable advance of the delta southwards during these years. Moreover, the coastal outline in Rennell's map is more uniform as compared to the broken outline of the latter survey. This also invites the question : Has there been more of coastal erosion in recent times ?

83. There is evidence of the "existence of parallel lines of sand dunes, once piled up on the verge of the sea," making "it certain that land building from the seaward has gone on there." How are we to reconcile all these ?

"Various explanations of the above phenomenon may be offered. The accuracy of Rennell's coastal survey is not above suspicion : it is related that he ascertained coastal distances by observing the difference in time between the flash and report of a gun fired in a boat moored off the coast." (L. R. Fawcett, *Final Report on the Khulna Settlement*, 1920-1926, p. 4.)



Though this may have, to some extent, vitiated the extent of the coastal area southwards, says Fawcens, it "would hardly account for the great difference between the coastal outline of Rennell's map and that of the topographical Survey of 1906." "The apparent solution," according to him, "lies in periodical earth subsidence," which would almost amount to coastal erosion. He reconciles the anomaly by saying, "If, then, after the inland lines of dunes had been formed during a period of earth quiescence, a period of subsidence took place during the period within which Rennell's survey fell, a subsequent survey would certainly show, as did the survey of 1906, that there had been apparent erosion since Rennell's time - inspite of the fact that old lines of sand dunes proved more ancient retrocession of the ocean in the same area."

"It does not appear," comments Mr. Majumdar, "that there has been any material accretion since Rennell's time except at either end of the delta face, as in the middle portion, all rivers have practically ceased to bring down any upland floods. It is no doubt true that they carry a large proportion of silt along with the flood tide with which they are trying to raise this lower portion of the delta. The source of this silt is what is carried by the upland flood carriers into the sea at either end, a portion of which is dispersed by the strong tidal current



along the delta face and remains mostly in a suspended state. It is hardly likely that any material portion of it would get a chance for consolidation or be able to extend the delta in the middle."

Without a detailed field investigation, it is really difficult to say anything conclusively on the above. Detailed investigation necessary Anyway, it is sufficiently clear that Rennell's survey might not have been so accurate as to lead us to think that there has been no accretion of land since his map was prepared.

CHAPTER VI

DISTRIBUTION OF POPULATION: AN INDEX OF THE REGIONAL BALANCE OF MAN

84. Man lives on earth and is found distributed on it in groups, large or small. This grouping of mankind—or rather the distribution of *population*, as it is termed—is found to develop some geographic patterns. These geographic patterns are based on the density of population, and such density is greater in one area and less in others. Why this difference in the distribution of population, is a moot question in all investigations of geography. There is no doubt as to the fact that man lives by exploiting nature, and, to do it efficiently, he forms communities. Where nature is more bountiful, a larger community will thrive on it. The reverse will be the tale in an area with less economic possibilities. So that, at any instant, the people will be thickest in an area which, according to the knowledge and efficiency of the community, is most suitable to maintain a greater number, and sparse in others. A glance at the population map, therefore, helps to form a fairly correct

idea as to the available resources in the region, and its concentration along particular places, for the population, too, would be similarly arranged. But one must remember that, besides natural resources, which are responsible for food and health, there are other factors influencing distribution of population, such as social ecology and cultural ecology that have not been included within the scope of the present enquiry.

85. The geographic pattern of the distribution of population then helps to some extent in understanding the ecology of the region. By ecology, of course, is meant the resultant expression of elements constituting the natural environment. Such elements are the climate, physical features, the soil, ground and surface water, plants and animals. This natural environment offers certain possibilities, which man, as a community, tries to utilise for his own needs. Some of the regions, like deserts, are inherently lacking in some important resources, whereas they are comparatively easily abundant in others. In some cases, however, the technical knowledge and efficiency of the community living in an area, though having great potentialities, may not be sufficient to develop it, as was formerly the case with Singbbum prior to the present century. But, everywhere it is felt, there are

certain limitations, imposed by nature, which cannot be overcome, and so the distribution of population is directed accordingly. "Man cannot bend Nature entirely to his will. He can go only so far regardless of ability, ambition, industry and perseverance: he cannot fish, if waters abounding in fish be absent: engage in lumbering, if forests be wanting, or even farm, if soils, climate and topography be overwhelmingly hostile. The *milieu* is indisputably a limiting factor in determining the ranges of man's effective choice of vocation" (White and Kenner, p. 676)

86 At one time, the pioneer European geographers laid too much stress on environment as determining the relative distribution of population. They thought that human affairs were greatly controlled by the environment in which the community was placed. The majority of the American geographers, however, regarded the issue in a different light. They contended that environment cannot direct man's activities, assuming to herself the role of a master. The same region might offer several types of occupation such as mining, lumbering and agriculture, as the Darjeeling Himalayas, and it is for man, according to his own knowledge and equipment, to choose any or all of them so that the role of environment is more in the neutral line.

To be more explicit, nature *influences* the activities of man rather than *directs* him to adjust

himself to the environment to the best of his knowledge and efficiency. But this influence acts within certain limits, so that a still better term would be that of 'human adjustment to the natural environment.' The nature of this adjustment finds expression in the geographic pattern displayed by the distribution of population.

CHAPTER VII

DENSITY IN RELATION TO ECOLOGY

87. But the adjustment of man with the environment is never a static process. The environment is ever changing, since the elements constituting the environment are never the same for any length of time. The climate, though apparently the same for a short period of time, becomes appreciably different when a much longer stretch of time is taken into consideration. Physical features, of course, do not change appreciably except in unstable portions of the earth where the dynamic agents of erosion and corrosion are keenly active as in the deltas, but they too have different significances to communities equipped with varying knowledge. The soil is a very sensitive element, constituting the natural environment, instantaneously responding to the hydrographic characters, climatic changes and agricultural practices. The rivers, in themselves a constantly changing aspect—advancing from infancy to maturity and subsequently to old age and decay—are further tampered by human activities. Utilisation of land for agriculture, besticulture or saxiculture affects plant and animal life, and its effect, too, is felt in the total composition of the environment.

88. Little wonder, then, that when all the elements composing the environment gradually change, man's adjustment to it will be likewise affected, so that the total expression, namely, the distribution of population, will be different in different periods, even in the same region. And here comes in the utility of the study of the distribution of population, which will serve to throw some light on the trend of environmental changes and the line in which the adjustment of man has proceeded. This adjustment might have been satisfactory and progressive or it might have gone in a wrong direction. Whether it has been satisfactory or not, will be reflected in the nature of variation of the distribution of population.

89. If then, the distribution of population be so closely dependent upon the way in which the adjustment with the environment is effected, it will be necessary first to study in detail the conditions obtaining in different parts of the region, which, in this case, is the delta of the Ganges.

90. The study of the deltaic region cannot be taken up all at once. Though the entire region geographically constitutes a delta, yet different portions of it present entirely unlike sets of characters. Probably no large region is truly unified. A careful scrutiny of any major unit

Study of Environ-
ment necessary.

Regional sub-
division unavoidable.

proves this. In order, therefore, to get a more accurate picture of the region, it is necessary to break it up into smaller regions, districts and localities. The composite picture can be made up from these afterwards.

91. But what units are to be chosen constitutes a problem by itself. The study of regional geography can be based on three types of units—political, natural and geographic. Each has its merits and demerits. A district, for example, may contain diverse characters in different portions—part of it may have one type of distribution and part of it another. Physical divisions, depending upon rivers, etc., too, may be similarly affected. Geographic divisions likewise combine distinct physiographic and hydrographic factors. But some sort of division must be taken, and in the present discourse, districts and subdivisions form major units as regards studies of environment, whereas, for population study, density figures, both of districts and of thanas, have been taken to be the units. Our studies will be confined to a period of 50 years from 1881 to 1931, subsequent to which no Census figures recording the density of population have been made public. Prior to the year 1881, there was only one Census, strictly speaking, but this cannot be depended upon, since the methods adopted to collect data cannot be relied upon.

CHAPTER VIII

EARLY ACCOUNTS OF POPULATION

92. The entire deltaic region, from Gaur (the apex of the delta) down to the southernmost fringe of the Sunderbans, appears to have been full of life and activity in the past. Most of the rivers in the deltaic region, which have since decayed or are heading towards it, were in ancient times dotted with ports and market towns where ships of Bengal and those from overseas called and carried merchandise. As investigation is proceeding, objects of antiquarian interest are being dug up, from amidst the wild regions of the Sunderbans, that bear unmistakable proof of the prosperity of these regions in ancient times.

93. As early as 150 A.D., from the map of Ptolemy, we get evidences of four towns not far from the sea, of which one has been identified with Tamralipti (modern Tamruk) by Bhattasali.* As regards the position of the other three, Bhattasali observes, " But the position of the

* *Antiquity of the Lower Ganges and its Courses*, Science and Culture, Vol. VII, No. 4, p. 232.

other three has yet to be ascertained. From measurements it appears that Poloara was situated in the longitude of Magrahat, in 24 Parganas, Gangeside in the longitude of Bagerhat, District Khulna, and Tilagrammon, probably on the Dakshin Shabbazpur Island. Places of antiquarian interest have disappeared from view in these regions owing to a great subsidence of the whole of Lower Bengal, which took place during the middle of the 6th century A.D."

94. "The Ganges estuary," comments Radhakamal Mukherji, "has had a chequered history, with which is connected the rise and decline of the sea ports of Bengal." Reference to Tamralupti (Tamluk) is also found in the Mahabharata, Vrihat Samhita, and the Ceylonese Buddhist chronicle, the Mahavamsa. Mukherji also suggests that the mention of a port "on the mouth of the river in Bengal probably alludes to Tamluk. This port, which was active even in 410 A.D. at the time of the visit of Fahien, gradually lost its importance as a port by the 7th century A.D., when another Chinese traveller, I tsing, described it as on an inlet of the sea.

95. This decay, which, according to Bhattasali, was due to subsidence, was, in the opinion of Mukherji, brought about by "the process of land formation, which has resulted in Tamluk, once situated on the seashore

(Velakulam), now being 50 miles from the sea. By the 10th century, the channel on which Tamluk was situated, and which afforded facilities of navigation, was silted up.*

96. It was not on the banks of the Hooghly only that prosperous habitations and ports were to be found. The whole of central and eastern Bengal also tells the same thing. "In the 14th and 15th centuries the trade of Saptagram, or Satgaon, suffered an eclipse. Gaur, the royal capital of the independent Sultanate of Bengal, had already been a magnificent city, five or six centuries before Christ, but she rose into greatest affluence in the 14th and 15th centuries. . . . The Meghna was then the principal route to the Capital of Bengal, the other being up the Bhagirathi. Chittagong, situated at the mouth of the Meghna, was then Bengal's chief port, and was named by the Portuguese Porto Grande (grand port), in contradistinction to their Porto Pequeno (small port) in Satgaon. Other important ports on the Meghna were Bakla, Sonargaon and Sripur. Fitch (1585) visited all these ports together with Tanda, Hughli, Saptagram and Chittagong. From Sripur he sailed for Pegu, passing down the Ganges and passing by the island of Sundiva" (Sandwip). The decline in the status of Chittagong as a sea

port, observes Mukherji, has been due to the decline of Gaur, the last being due to the Ganges receding westwards, leaving long shallow marshes behind it. Fever followed and depopulated the city, the final epidemic of 1575 being so terrible that the dead could be neither buried nor burnt, whereupon the few survivors fled from the place.*

97. Similar places of importance are also to be noticed in the contemporary records. "Bakla, Tripura, Sripur and Chandecan in the south were also important markets of rice and cotton cloth in the medieval period," while, speaking on the decline of western and central delta, Mukherji observes, "The chief centres of Bengal's export trade in the Moghul days were Satgaon, Chandecan, Piphi, Dacca, Sripur and Sonargaon, excluding the various foreign settlements which were gradually rising into importance. The principal centres of ship building at the time of Mir Jumla and Shasta Khan (1664) appear to have been Hughli, Baleswar, Murang, Chalmari, Jessore and Karibari," where as many boats were ordered to be built and sent to Dacca as possible (Mukherji, *Indian Shipping*, p. 227). The District of Jessore is still full of marks of old river beds and of the memories of Iswaripur,

* R. K. Mukherji, *Changing Face of Bengal*, p. 159

Dhunghat, Jahaghat and Chakasri, now hardly to be recognised as scenes of naval glory."*

98. That the population, apart from spreading in upper and central portions of the delta, extended down to the coast of the Bay, will be evident from antiquarian evidences as observed by Bhattasali :—

" But objects of antiquarian interest very often turn up from these wild and desolate regions, testifying to their inhabited character and prosperity in remote days. The discovery of a copper-plate inscription of Dommanpala, dated 1196 A.D., from the Rakshaskhal Island, about 12 miles direct east of the Sagar Island, on the Bay of Bengal (*Indian Historical Quarterly*, 1934, p. 321), of the copper-plate of Jayanagar (about 600 A.D.) from Malaya, 15 miles south-east of Diamond Harbour (*Epigraphica Indica*, Vol. XVIII), of a plate of Lakshmana Sena at Bakultab, four miles to the east of Malaya (N. G. Majumdar, *Inscriptions of Bengal*, Vol. III, Appendix), of sculptures of the Gupta period from Kashipur, about five miles to the north-east of Jayanagar P.S., 24 Parganas (*I. H. Q.*, p. 202), all tell the same tale."

99. Regarding a number of earthen seals of pre-Muhammadian days, Bhattasali observes,

* R. K. Mukherji *Changing Face of Bengal*, p. 179



"These were also discovered in the island of Rakshaskhal. They are inscribed with dates and years in the script of about 11th century A D. From some of the dates which closely follow one another, he suggests the briefness and regularity of the correspondence received. He concludes by saying, "Thus is not the place for a detailed notice of these seals but they also bear out the inhabited character of even small islands on the sea-board, like Rakshaskhal." "We can only hope," proceeds he, "that progressive reclamation of the Sunderbans will lead to the discovery of the ruins of the three cities mentioned by Ptolemy."

CHAPTER IX

DEPOPULATION OF THE LOWER PART OF THE DELTAIC REGION

100. From the above résumé of the past decades, beginning from the time of Ptolemy at least up to the 17th century A.D., the whole of the deltaic region seems to have been fairly inhabited by people, because, otherwise, no trade, commerce and development of markets and towns would have been possible. As for the decay of population in the central and upper parts of the deltaic region, one can find some clue by studying the conditions in these parts in the last five or six decades and suggest reasons. The matter will be taken up presently.

101. But before that, a consideration of the Sunderbans region bordering the sea deserves some notice. Before reclamation had proceeded in the Sunderbans regions, the country was not even opened up. It has since been lying in this wild condition, out of humanity's reach, at least up to the time of Rennell, who in his atlas of Bengal, Sheet No. XX, 1761, marks the entire southern part of the Bakarganj District

as "Country depopulated by the Maghs." This depopulation, contends Bhattasali, was due to "The ravages of the Magh and Portuguese pirates who during the first half of the seventeenth century swept the whole of the Sunderban region clean of human habitation and consigned the entire area to rank vegetation" "aided by gradual subsidence of the Delta"*

102 50 years ago, in his *Revenue Survey Report on the Districts of Jessore, Faridpur and Bakarganj*,
 Earth subsidence
 Colonel Gastrell recorded evidences of buried forests of Sundri trees. "At Khulna, about 12 miles north of the nearest Sunderbans lot, at a depth of 18 feet below the present surface of the ground, and parallel to it, the remains of an old forest were found, consisting entirely of Sundri trees of various sizes. . ."

A writer in the *Calcutta Review* of 1859 (*The Gangetic Delta*) also gives another evidence of such submerged forest from Canning 'at the head of the Matla' In excavations, over a greater part of the lower delta extending up to Calcutta, such trees have been unearthed † This,

* "Places of antiquarian interest have disappeared from view in these regions owing to a great subsidence of the whole of lower Bengal, which took place during the middle of 6th century A D" - *Science and Culture*, Vol. II No. 5, p. 236 (vide Paragraph 99)

† Similar evidence was also found while excavating foundations of the Lock at Rajore on the Kumar river about 10 miles north of Medinipur. - S. G. Majumdar.

together with the presence of Calcutta peat all tend to bear testimony to the fact that there has been a subsidence in the lower part at least, if not throughout the entire deltaic region.

103. This fact of subsidence has been utilised by some historians in trying to account for the depopulation of the once thriving area of the Sunderbans. "The subsidence of the Sunderbans is a subject dear to the heart of antiquarians and historians of Khulna District, for on this assumption they account for the traces of ancient civilisation in the heart of muddy jungle where no man could now live. That these remains do exist is an undoubted fact." "I have seen," observes L. R. Fawcett, "the remains of palatial buildings and temples not only in newly reclaimed land, but actually many miles within the muddy mangrove swamps of the reserved forests; without agreeing with the writers who hold that the existence of these buildings is a definite proof of the theory that a once populous Sunderbans has become uninhabitable owing to earth subsidence, it is still fair to say that their existence fits well with the above theory."

104. Still another view brings in the devastating action caused by cyclones and the irremediable storm-waves that might have compelled the inhabitants to quit the Sunderbans for a safer region northwards. Instances of the widespread

Cyclones

havoc and terrible inundations caused by such tornadoes are very frequent in the coastal regions



Reproduced from the *Amrita Bazar Patrika*

In giving an account of the Bakarganj Cyclone of May 25, 1941, the *Amrita Bazar Patrika* of July 13, 1941, reproduced the following from *Science and Culture* :—

"The daily papers for the last one month have been full with accounts of the terrible cyclone which swept over the islands at the mouth of the Meghna (the combined course of the Ganges and the Brahmaputra) and the adjoining districts of Backergunge (Barisal) and Noakhali on the night of May 25, causing widespread havoc to life and property. The loss of life has been estimated at 5 to 10 thousand, the destruction of property at amounts running to crores. The economic life in the stricken regions has been ruined, and it may take full one generation to recover from its effects."

105. "Cyclonic disturbances are familiar phenomena at the head of the Bay of Bengal," the article goes on, "but the havoc caused by them do not *usually* reach catastrophic proportions unless they are simultaneous with tidal waves. 'This was unfortunately the case on the present occasion, the night of May 25 was just before new moon. A similar combination was also responsible for the far greater catastrophe of 1876 when a full moon tidal wave followed by a cyclone swept over the very same regions, and caused the death of over 4,00,000 men. It is reported that the very same region was visited by similar catastrophic cyclones in 1584 and 1822."

106. The same paper also gives a brief account of the cyclone of October 31, 1876 :—

" Although the present severe cyclone storm has done very great injury to life and property it was far surpassed by the famous Backergunge cyclone of October, 1876, an account of which has been left by Sir John Eliot. At that time over 4,00,000 persons were drowned in the floods caused by the simultaneous action of the tidal wave and the storm wave in the districts of Backergunge, Noakhali and Chittagong. The flood water is said to have reached 45 feet at Mephna, and was about 10 or 20 feet on the average in the total area inundated. The total area affected by the cyclonic storm extended over 3,000 square miles "

107. Thomas Oldham, for example, " feels convinced " " that there is no ^{increasing salinity} necessity to resort to any fancied effects of cyclone waves, of the inroads of pirates or the persecution of other peoples, to account for the occurrence at the present time of ruins in the Sunderbans."

" The very first necessity for the existence of man is the presence of drinkable sweet water. Where this cannot be procured, it is certain that man can make no settlement, and it is equally certain that the removal or destruction of the sources of supply of this necessary element of existence will compel him to abandon his abode, and change his habitation. We have not to go beyond the delta of the Ganges itself to see

the application of these facts in explanation of the former history of the Sunderbans. The more modern courses of the large rivers give us a patent illustration of the successive conditions of all. To the east where now the great body of the waters of these rivers is discharged, we find the force of the fresh water sufficient to overcome the strength of the tide and the influx of salt water from the sea. And down to the very mouths of the rivers here, fresh water (often for hours in the day flowing over a basis of salt water beneath) can readily be

Importance of fresh
water

procured. The consequence is that towns and villages line the banks of every stream, and population and cultivation follow the course of this the prime element of their existence. To the east, as we have said, the filling in of the delta has not yet reached the same level as to the west, and the fresh waters here retain sufficient power, therefore, to be carried down to the sea. In earlier times, precisely similar conditions must have existed further to the west; the larger portion of the river waters found their exit through the channels there, and were thus in sufficient force to be carried down to the very sea; and the natural consequence of this was that man fixed his abode where he could procure fresh water, towns and cities arose, and taking advantage of the great facilities for trade offered by their position,

increased in importance and number, until the necessary changes in the course of the stream which supplied them deprived them of the possibility of existence."

108 In support of the above observation, Dr. Oldham further writes, "That this is the natural interpretation of the facts appears to me abundantly evidenced by the circumstance that within this abandoned tract and in its vicinity, at the present day, when the swarming population seeking utility for settlement in every direction, not a single spot finds its settler, save where fresh water is to be had: and the traveller may go for days or weeks through the countless anastomosing creeks and channels of the Sundarbans, without finding a single abode, whereas the moment he reaches any spot where fresh water is obtainable, he finds cultivation spreading and population increasing."

109 Dr. Thomas Oldham clearly points out that "Cyclone waves and persecution and robbery do not drive men from their abodes near the seaboard now, though they may cause vast destruction of property and produce great suffering . . . unless combined with the far more general and more unavoidable compulsion of the want of water. . . ."

* *Proc. Asiatic Soc. of Bengal*, 1870, pp. 47-51

110. In support of the above theory sponsored by Oldham, O'Malley* cites the instance of Gobra, a village on Kobadak. It was once prosperous when that river was active and maintained its health and agriculture, and also supplied good drinking water, but now was decaying along with the decay of the stream and was fast being deserted by the inhabitants.

* *Bengal District Gazetteers—Khulna*, p. 6.

CHAPTER X

EARLY ESTIMATES OF POPULATION

111. The first evidence of systematic enumeration of population, ^{British period} however inadequate, was attempted in 1872. Prior to this attempts were made from time to time, but they were entirely unreliable, judging by modern standards. The following, reproduced from the Census Report for the decade 1901-11, Vol. V, p. 61, would throw some light on the dependability of such accounts of population.

112. "The basis of the calculation varied widely, and some of the figures appear so extraordinary in the light of our present knowledge that it is surprising that they can have been accepted at all; . . . as for instance, in Chittagong, the figures were based on an estimate of the area under cultivation coupled with an assumption that each cultivated acre supported six persons. As a rule, however, the estimates were based on the number of houses and the average number of persons supposed to live in each, the average, though generally taken to be five, was sometimes four and in one case as low as two and a half. How haphazard these estimates

were, may be realised from the experience of Sir Henry Thudler, then a young lieutenant, in charge of the revenue survey of a Pargana in Sylhet from 1839 to 1841. In 1841 he reported to the Deputy Surveyor General that he did not know that he was expected to undertake a Census, and that it would be difficult to make the count so late in the day. Major Bedford, Deputy Surveyor General, reprimanded Thudler, though he candidly admitted that the mistake had probably resulted in economy; if the houses were counted and multiplied by a certain factor, that would suffice. Thudler then pointed out that this gave no indication of the numbers of the sexes, but even this did not defeat Major Bedford. He seemed astonished that Thudler's wanderings in Jaintia had not given him a tolerably accurate idea of the relative numbers of sexes and eventually the numbers were assigned on Thudler's visual knowledge of the Pargana. Afterwards, in 1851-52, Thudler himself . . . showed the figures for Jaintia as having been obtained by a 'Census taken of the population' "

113. The Marquis of Wellesley called for information regarding the population from the Collectors and Judges stationed in the Districts in the year 1801, but "the returns were so imperfect and, when they were made by those two descriptions of the officers, so contradictory that no general conclusion could be drawn from

them. . . . Nothing more has yet been produced than the estimates of ingenious men who differ considerably among themselves" (Fifth Report of 1812).*

114. We cannot, then, look to the systematic countings of population in the early part of the last century or prior to that. Nor can we hazard a pattern of what the distribution of population of those days might have been like. Some idea, however, might be formed as to the scattered nature of the centres of population, from the 'early official reports and correspondence of the East India Company's servants' W. H. Thompson, in *Census Report, 1921*, Vol. V, p. 20, makes the observation that ". . . the population was distributed in a manner very different from its distribution today . . . A hundred years ago," proceeds he, "there appear to have been stretches unbroken by cultivation for considerable distances in parts of every district, cultivators could always migrate and often did so† from one pargana to another and had no difficulty in finding land which they could take up." As to the way in which population centres used to

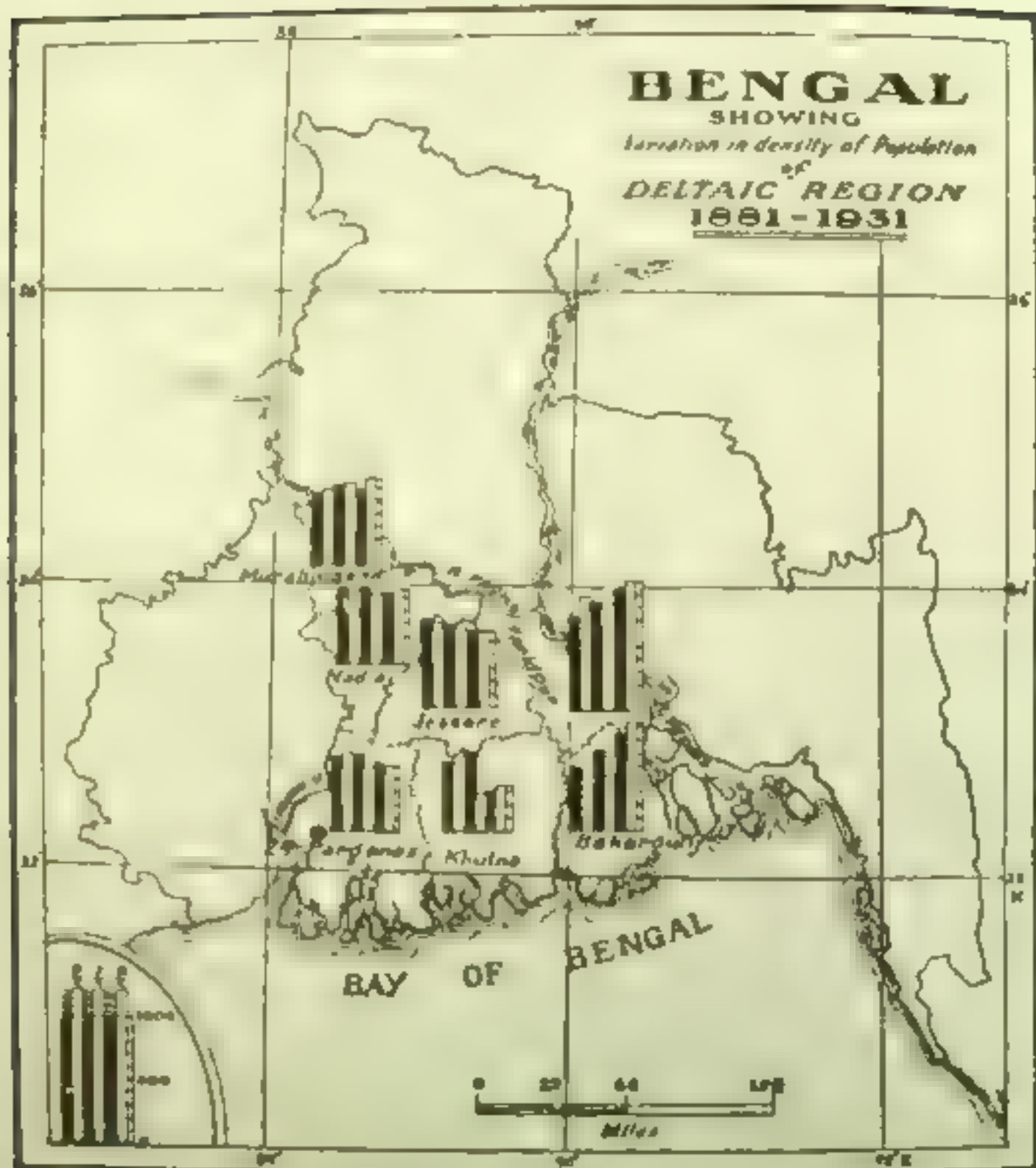
* *Census Report, 1921*, Vol. V, p. 21.

† As the terms *Khashtat raryat* (in the estate in which his home-stand stood) and *Parkhat raryat* (in an estate in which he subsequently took up land) signify

grow up before the regime of the British. Thompson suggests that "Cultivators settled round" the residence of a powerful prince who would be able to protect them, and for many years afterwards centres of population, which had become so in those days of stress, remained. These were instances of military colonies which the Moghuls deliberately made centres of population by establishing soldiers as cultivators. One such was formed by the two parganas Dandra and Jugidia placed in the east of Noakhali District to form a bulwark against the Arakanese."

115 Compared to other regions, the larger density of population in Kushtia in Nadia and Chhagalnaiya in Noakhali (also Puthia in Rajshahi, Rangpur and Thorla in Tippera), as enumerated in the Census of 1872 has been suggested by Thompson as being due to the great security enjoyed by cultivators in comparison with previous times.

116. Next he passes on to make the rather sweeping generalisation that "By 1872, however, the raids of the Marathas, the Assamese and the Maghs as well as the internecine strife among the nobles of Bengal had been forgotten and the population had spread over the whole face of the countryside much as it is today, so that the figures of the Census of 1872 show very few police stations under which the population was less than 300 to the sq. mile."





117. Mr. Thompson has considered only the political side of the problem. This aspect, namely, security from invasion, though important in itself, is not the only factor in the spread of density. Other elements of natural environment come in, which must also be considered.

118. The early estimates of population that have been given in Chapter IX, are not confined to the deltaic region only, but are rather a more general account of the whole province. From 1872, onwards, Census figures giving detailed accounts of the different districts are available. But, since the Census of 1872 is not sufficiently accurate and elaborate, the actual variation of density has been traced from the year 1881 and continued up to 1931, after which year no further Census figures have been published.

CHAPTER XI

ECOLOGICAL CONDITIONS IN THE MORIBUND DELTA

119. It has already been said that the delta, depending upon the conditions of rivers and land building, can be divided up into three parts. One such part is the 'Moribund' delta where rivers have ceased to be in the active stage and land building has been arrested. The geographical extent of this Moribund Delta covers the districts of Murshidabad (eastern part only), Nadia, Jessore, western part of Faridpur (Goalundo Subdivision) and small portions in the north of Khulna and 24 Parganas. Since it is not convenient to discuss the environmental conditions of the whole region together, each of the districts comprising the division will be taken up *seriatim*.

MURSHIDABAD

120. The eastern part of Murshidabad is bounded on either side by the rivers Bhagirathi and Padma, Jalangi forming the base of the triangle. The banks of the Bhagirathi and Padma have been

raised so high that the natural drainage of the area does not escape through any of them but finds an outlet through the Bhairab, Sialmari and Gobra Nala, all of which ultimately find their way into the Jalangi.

121. The tract has been mostly built up by the spill waters of the Bhagirathi and the Padma, the Bhairab, the Sialmari and the Jalangi also having partly contributed to this work of construction. The Bhairab, the Sialmari and the Jalangi, now, do not carry much silt, as the points of their offtake from the Ganges have been dammed by deposits of sand-banks. The Bhagirathi and the Padma are yet active but are prevented from spilling inland by high embankments. That the Bhagirathi was active till recent times is evident from the following statement of Dr. G. O.

Effect of embankments.

Chatterjee, " In dry season, the Bhagirathi entrance from the Ganges is often blocked by sand bank, not allowing even a country boat to pass through, and though this was observed even so far back as 1686 by Tavernier, yet even now so much water passes down the Bhagirathi during flood season every year from the Ganges, that it makes it not only a living river but a dangerous one, the spill water passing over its left bank, . . . has assumed so much proportion that a series of six embankments mentioned above,

one behind the other, had to be made to prevent this formidable spill flooding the land lower down. From 1801 to 1907, the main *bund* was breached 13 times, and as much as 50,000 cusecs of water passed through the breach in the *bund* which became in one year half a mile wide, a vast sheet of water reaching to near Bongaon, flooding 2,800 square miles." After this, Chatterjee adds in a foot-note, "Stewart and Proctor in submitting their report to the Drainage Committee of the Presidency Division, stated that 'in the parts of the Bhagawangola and Laligola thanas lying outside the retired line of the embankment, the country is completely flooded from the Bhagirathi river during the rains, and many of the villages have to be evacuated by the inhabitants who live on the top of the embankments until the flood go down'" (Appendix of the Report of the Drainage Commissioners for the Presidency Division)

122. Gobra Nala affords another instance of how man (either consciously or not) interferes with the action of nature. "The Gobra Nala is a channel running from the Bhagirathi to the Jalangi at Bah, a distance of about 50 miles. It was probably originally an effluent of the Bhagirathi, and it is, in fact, the natural drainage channel for the country east of that river. The action of nature, however, has been interfered

Embankment
affects drainage.



with by the construction of a marginal embankment along the left bank of the Bhagirathi, called the Labtakuri or Naltakuri embankment, which extends from Jiaganj to Bhagwangola via Kalukhali and has cut off its connection with that river. Its offtake being closed, it receives only local drainage water south of the embankment. It has silted up in its lower reaches but still has a good deal of water in the portion lying to the east of the Sadar Subdivision; further north, in the Lalbagh Subdivision, it is much narrower and in many places is merely a marshy depression."

123 Whether man, by accident or design, ^{High} ^{banks} has built up the embankments, ^{accelerate} ^{decay} or they have grown up chiefly ^{rivers} through the action of nature, it is clear that the land has been deprived of spill water from the rivers. The result has been that the rivers are elevating their beds so fast that a greater and greater quantity of water will pass to the Meghna side through the Padma to the detriment of the Murshidabad rivers. On account of this spill of the Bhagirathi being prevented from spreading over the whole of the delta, the area above embankment is rapidly rising in height, being as much as three inches each year, so that one can understand that the Ganges water during flood season will pass in future less and less into the Bhagirathi if this

rise goes on uninterrupted, as the Ganges will find a more easy escape for the passage of its waters in the Meghna than through the Bhagirathi.

124. Another very important result of the prevention of inundation from the Bhagirathi and Padma, which is invariably accompanied by a rich spread of silt over the entire region, has been very wide in its results. For it has affected soil, irrigation, climate, health and production of crops in this area.

125. If the inundating action of a river with its consequent deposition of silt be prevented, the soil ultimately tends to become impoverished. This holds true even in the case of fields receiving abundant and regular rainfall and served with irrigation by clear water. The following excerpts will substantiate this:—

(i) "It was shown by the Director of Agriculture in the evidence given by him before the Irrigation Committee that even in an area where rainfall was supposed normally to be adequate, the yield in most years could be unproved materially by irrigation even with plain water, and in another connection he estimated that silt water would give an additional yield of 25% if not more." (H. P. V. Townend, *Development of Decadent Areas in Bengal*, p. 3)

(ii) "The Ganges, as it flowed on, filled up, with its lighter silt, . . . the valley occupied



by Murshidabad, Nadia and northern Faridpur, whose soil, in very great part, is composed of the light silt which is so easily eroded, so soon dry, and so desperately in need of irrigation with the clayey water of the surface flow of the Ganges flood. This muddy water is not only needed to renew the fertility of the soil and to combat malaria, but also to arrest the increase of that dangerous Kansgrass which, when left alone, is capable of rendering the land quite sterile" (W. Willcocks, *Ancient System of Irrigation in Bengal*, pp. 12 13.)

(iii) "The fertility of the soil has declined owing to the loss of inundation silt, and the rivers have deteriorated as a result of the Ganges having marched eastward. The deposition of silt is indispensable for the maintenance of fertility of the deltaic soil, constituted generally as it is of sand and loam when the rivers have become moribund and failed to supply silt, agricultural yield has rapidly declined, causing considerable land to be fallow and revert to jungle." (R. K. Mookerji, *Changing Face of Bengal*, p. 74.)

126. That the decay in the conditions of Murshidabad commenced from about the beginning of the last century is known from contemporary writings. "At the beginning of the last century," writes C. A. Bentley, "Cossimbazar Island, as the

Former fertility

portion of Murshidabad lying between the Ganges, the Bhagirathi and the Jalangi rivers was then called, was both exceedingly well cultivated and very populous. Lieutenant John Pester stated in 1865 that Cossimbazar Island was then in a state of fertility equal to any garden."

The Imperial Gazetteer records, "The decay of Cossimbazar dates from the Decay starts from beginning of 19th century beginning of the nineteenth century, when its climate, which had previously been celebrated for its salubrity, underwent an unexplained change for the worse, so that the margin of cultivation receded and wild beasts increased."

127. This decay has been partly due to Causes natural partly man made the fact that the rivers Bhairab, Jalangi and Sialmani, flowing through the tract, have suffered a natural decay due to the progressive eastward movement of the Ganges and deposition of sand-banks at their own heads. The natural set-back has, however, been further accentuated and hastened by human interference, wilful or not, as the following quotation from the *Census Report, 1901*, shows :—

"The district of Murshidabad is bisected from north to south by Bhagirathi. . . East of this river, the soil is low-lying and alluvial and forms a part of the old delta. It is fertile but liable to be flooded by the spill of the Bhagirathi

and other rivers, to prevent which numerous embankments have at various times been erected. The most important is the line of embankments along the left bank of the Bhagrathi. The propriety of maintaining all these embankments has often been called in question. The land which would otherwise be flooded is thereby deprived of its supply of fertilising silt and the river being confined to its bed deposits its silt there and thus gradually raises itself above the level of the surrounding country."

128. This prevention of spill from the Bhagrathi and the Padma, or the arrest of 'red water' as it is called, has not only affected the land and impoverished the soil but has also made the area remarkably insalubrious. This is because inundation, and the silt it carries, both have a remarkable effect on health. "Two of these factors, rainfall and inundations, also exert an important influence upon Malaria, heavy rainfall and widespread inundation of the land surface tending to check the breeding of anopheles mosquitoes, whereas short rainfall and scanty inundations favour their increase. Hence the relative prevalence of Malaria is largely influenced by the same conditions which determine either a good or a bad harvest." The above is an excerpt from the considered opinion of Dr. C. A. Bentley.

129. As soon as rivers are confined within artificial banks and natural levees, in either case the level of underground water also varies. The formation of levees or construction of embankments in rivers mean that they are usually flowing at a level higher than the level of the land on either side. Presence of water inside the channel of the stream at a higher level necessarily raises the water table, so that underground water comes very near to the surface and in some cases appears above. When this is the case with underground water, no rain-water is allowed to percolate below and it has to accumulate in between the high walls of the natural levees or artificial embankments as the case may be. Such accumulations of standing water convert the land to marsh and prevent agriculture. They also create further troubles by serving as breeding grounds for mosquitoes and favourable haunts of certain moist weeds.

130. Agricultural conditions in Murshidabad —and, for the matter of that, in any part of the deltaic region —is as intimately bound up with inundation and silt as the question of health. Commenting on the problem of agricultural deterioration in Murshidabad, Bentley observes, "Agricultural deterioration has also occurred in the Murshidabad district and has been

associated with a coincident decline in the public health. In 1809, Lord Valentia remarked of the Murshidabad district that 'The annual overflow of the river leaves a deposit of mud, which, like that of the Nile, gives richness to this otherwise barren country.' In 1838, Montgomery Martin mentioned that the climate of the Murshidabad District had deteriorated 17 or 18 years previously. 'The unexplained change for the worse,' detrimental alike to agriculture and population, appears to have been directly associated with the cessation of the periodical inundations, which used formerly to enrich the soil, and the decline of agricultural prosperity which followed was also accompanied by an increase of malaria. . . ."

131. So then, briefly, we have the following conditions in Murshidabad :—

Summary of the conditions in Murshidabad.

(i) Banks of the Bhagirathi and the Padma have been raised (partly by nature and considerably by man) above the general level of the country, with the result that the inland area is no longer completely drained, and marshes and stagnant pools are increasing.

(ii) The level of subsoil water has risen higher, resulting in the formation of numerous marshes.

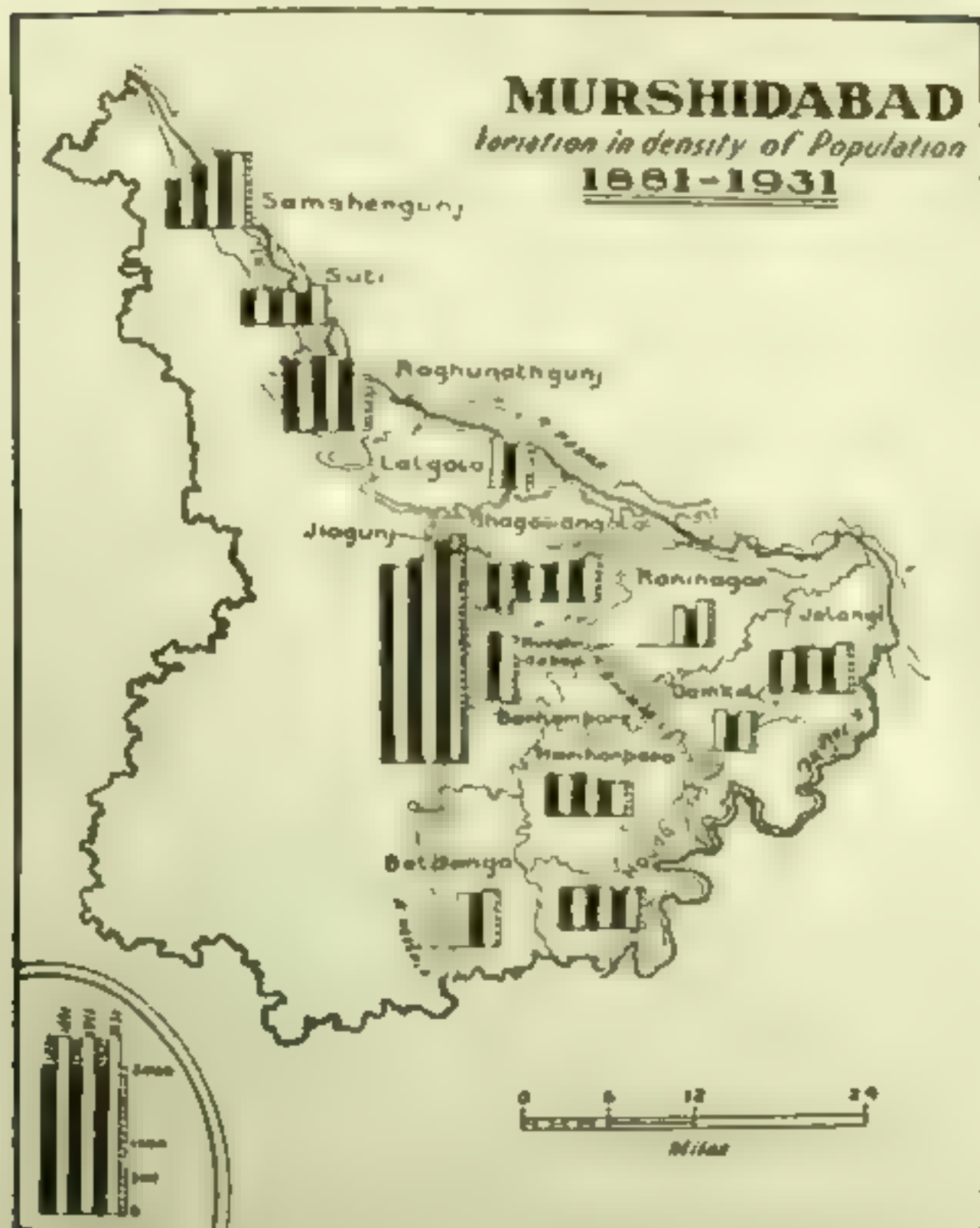
(iii) Silt and spill of the rivers having been arrested, lands are gradually impoverished.

(iv) Fertility is diminishing and insalubrity increasing since the incidence of obstruction to drainage and prevention of spill.

132. The net result of all the above has been that the environment is becoming less and less suitable to support a dense population.

The natural result would be a diminution in density or an increased effort on the part of man in order to re-establish his mastery over environment. Since this latter effort is markedly absent, the former has operated in the present instance. This is clearly shown in the graphs illustrating variations of density of Police Stations since 1881.

If the density for the district as a whole be considered, it has varied within the range of a little less than 600 in the year 1872 and the same for 1881 to just short of 700 in 1931. If that for the total population of the district from the year 1881 to 1931 be considered, it also shows the same trend. It begins from the neighbourhood of 11,20,000 in 1881 and ends in 13,70,677. When the individual thanas are considered, excepting Berhampore and Samshergunj, which two thanas maintain a steady increase, all the others continue almost horizontal with little ascents and descents. Hariharpara shows, however, a steady decline. The rise in Berhampore has been due to better sanitary conditions and



addition to the Municipal area, whereas the reason for increase in Samsbergunj is due to the fact that Samsbergunj, being outside of the zone of embankment, benefits from inundation from the Bhagirathi and the deposition of the silt.

133. One characteristic feature to be noticed in all the curves, whether for density of each thana, or of the district as a whole, or of the total population, is that they invariably suffer a drop from the year 1911 to 1921 and then again begin to rise. This is explained by the prevalence of an epidemic fever that ravaged the entire region of the moribund delta. *The Census Report for 1921* (Vol. V, p. 57) makes the following observation as regards the decrease in density for the last 20 years :—

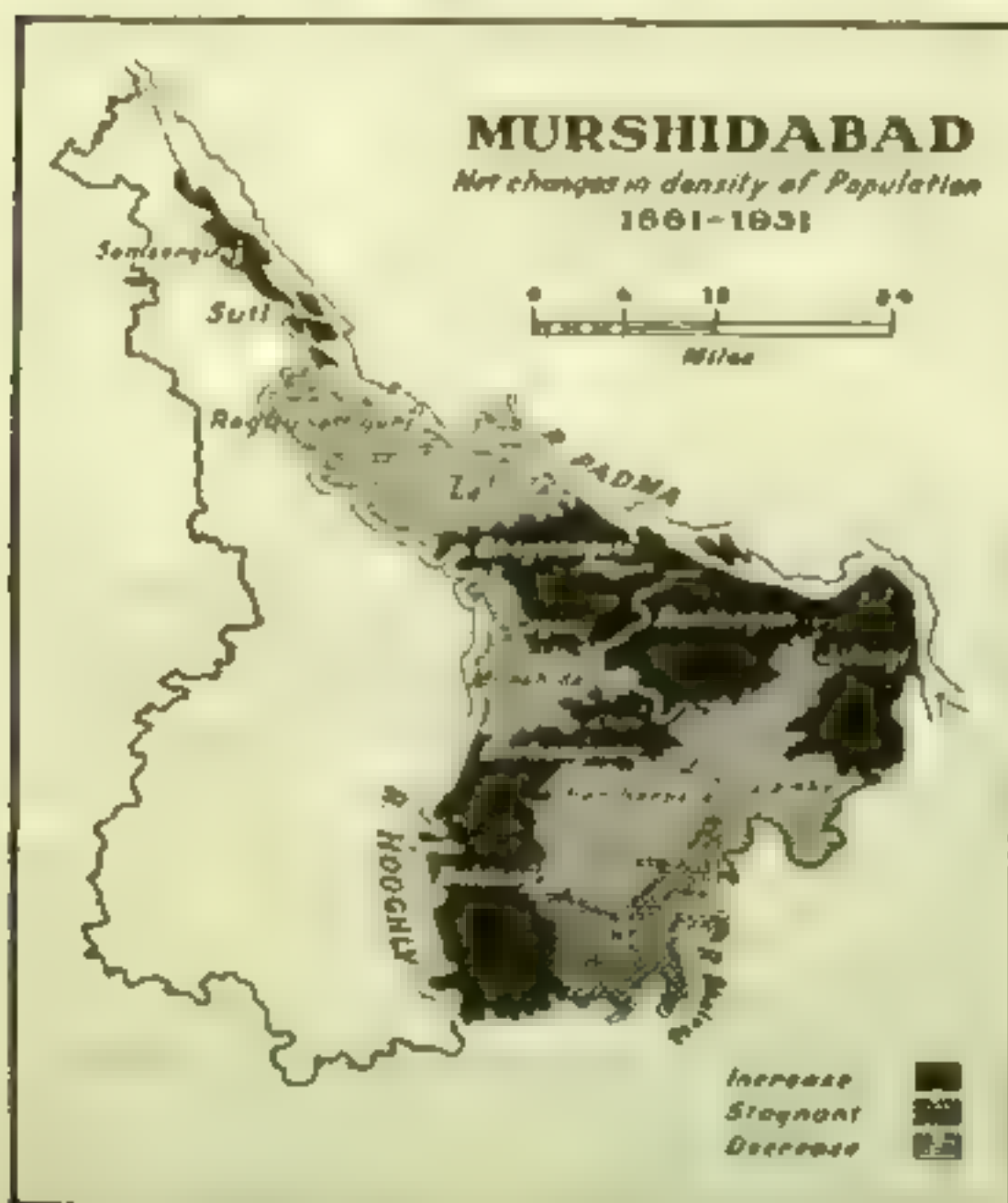
" The result of the 20 years (1901-1921) has been to make the number of emigrants now nearly twice as great as the number of immigrants. Partly this is due to the fact that immigration to the western parts of the district from the Santal Parganas and Birbhum has been stayed and the native born children of immigrants have taken the place of their fathers, but the density of population is less now than it was 20 years ago, and that the proportion between immigrants and emigrants has changed in this manner is significant of deterioration in the reproductive capacity of the soil at the

hands of a fever-stricken agricultural population. The figures for migration seem to indicate that Murshidabad suffers more severely even than Nadia from the evils which have come about by the decay of the distributary river system from the Ganges, the consequent fall in the subsoil water level and its concomitant distributaries."

134. The general rise in all the graphs, excepting for the thanas of Raghunathgunj, Murshidabad and Hariharpara, has been accounted for in the *Census Report, 1931* (Vol. V, p. 44), as "due to the ordinary recuperation generally noticed when a calamity has reduced the population. Specific explanations are offered only for Domkal and Jalangi police stations which owe their increases to a healthy climate and the settlement of immigrants in Jalangi police station as a result of erosions in the river Padma elsewhere." The steady decline in Hariharpara has been due to the malarious nature of the place and the drop in Raghunathgunj between the years 1921 and 1931 (which seems unnatural in comparison to other police stations) is due to "a number of silk workers leaving the locality in which some areas have subsequently run into jungle." The decrease in "Beldanga and Murshidabad police stations is difficult to assess," because they were differently distributed in the Census of 1921.

135. The chief points to be noticed in the above study of the eastern part of the Murshidabad district are the following :—

Nature of adjustment.



- (i) From historical evidences and contemporary records it is learnt that the Murshidabad

District was once very prosperous and, apparently, had a dense population.

(ii) Natural condition of the rivers began to worsen towards the end of the last century. A number of embankments were also built up then, obstructing the natural drainage and spill of the Bhagirathi.

(iii) The land was impoverished, the climate became unhealthy and production declined.

As the environment changed, it set into operation the process of readjustment, in regard to which two ways of adaptation are open — either the land has to be retained in former prosperous condition so that the density might not suffer a check or decrease, or the people must diminish in number so as to be in keeping with the sustaining capacity of the soil. Natural checks in the form of decreased birth rate and the prevalence of disease set in and a great part of the pressure was relieved by emigration outside the district.

NADIA

136. The next district adjacent to the south-east is Nadia. There seems to

Drainage

be no definite line of drainage.

"The country is flat and the general aspect is that of a vast level alluvial plain, dotted with villages and clusters of trees and intersected

by numerous rivers, backwaters, minor streams and swamps. In the west of the district is the Kalantar, a low lying tract of black clayey soil which stretches from the Murshidabad District through the gap in the N.W. boundary between the Jalangi and the Bhagirathi down into the Kaliganj and 'Tehatta thanas' (*Bengal District Gazetteers—Nadia*). The report of the Drainage Committee, 1907, also mentions that backwaters, minor streams and swamps intersect it in all directions.

137 The rivers flowing through or forming the boundary of the district
 Condition of rivers are the following :—

(i) Padma, though an active river in itself, has a spill over the area only in high flood.

(ii) Beginning from the north-west, the next river, forming the boundary between the districts of Murshidabad and Nadia, for a greater part of its course, is the Jalangi. In recent years, its head has been silted up and its flow is now being maintained by the Upper Bhairab and the Sialmari.

(iii) The next river is the Bhairab, which was once supposed to be continuous with the upper part of its course in Murshidabad. It now, however, takes off from the Jalangi " and after a most tortuous course across the district, the general trend of which is to the south, loses itself in the Mathabbanga not far from Kapas-

danga. During the greater part of the last century there was very little current in this river owing to its offtake from the Jalangi having silted up; . . . for many years past it has been practically dead, and the unhealthiness of Meherpur, which lies upon its banks, is in great measure attributed to the stagnancy of its waters."

(iv) When we consider the case of the Mathabhanga, which takes off from the Padma, we find that dredging operations were necessary near its head as early as 1820 "In 1820 on the Mathabhanga, and in 1824 on the Bhagirathi and Jalangi, regular measures were undertaken with the view of maintaining open channels for navigation, and these have continued till the present day, though with only moderate success. . . . Recently dredging has been tried, but it is yet too early to forecast the result" (*Report of the Drainage Committee, 1907*)

(v) Then there are several rivers taking off from the Mathabhanga, south eastwards. They are the Kumar, which is reported to have "deteriorated within recent years," the Nabaganga, the Chutra and the Bhairab (lower portion). The offtakes of all these rivers from the Mathabhanga have been silted up so that the rivers have lost their heads. In their lower portions they serve only as drainage channels, collecting the rain water and passing it on southwards.

(vi) The Betna and the Kabadok are the two distributaries of the lower portion of the Bhairab which are also in the same state of decay as the parent river.

(vii) The Ichamati and the Churni are the two rivers which still maintain connection with the Mathabhanga, but they have no vigour now.

(viii) The Garai, which is perhaps the most active river in the district, has thus been described (in the *Bengal District Gazetteers Nadia*), "The Garai is gradually silting up and is now navigable only during the rainy season." The condition of all these rivers has been thus summed up in the *Report of the Drainage Committee, 1907*, "It is between the Mathabhanga on the west and the Madhumati on the east that the area *par excellence* of decaying rivers lies."

138. The effect of all these decaying rivers, and the cross channels joining them, has been that widespread inundation and dropping off of silt have been prevented. It is only in years of high flood that some quantity of flood water from the Ganges spreads over the bordering regions of the Jalangi, the Mathabhanga and the Garai; but they do not cover the entire area. The marshes are not drained and fields are not replenished with silt, with the result that "The cultivators till the land for two or three years and then allow it to be fallow for a year or two, the fertility of the soil not being

Inundations rare

sufficient to allow of uninterrupted cultivation. . . In earlier days, before the rivers had completed their work of land making, the district was far more liable than now to considerable inundations, which, although they might destroy the crop which was actually standing at the time of their visitations, brought with them a coating of silt which ensured an excellent outturn for the following crop. This enrichment of the soil, however, no longer takes place as frequently as it used to, and as the very light manuring which is applied is insufficient to compensate for the loss occasioned to the soil by cropping, there can be little doubt that the land is getting less and less capable of giving a good return. . . It is becoming increasingly necessary to allow the land to lie fallow for longer periods. . .” (*Bengal Census Report, 1901.*)*

139. Not only the land and the crop but also the state of health has been considerably affected by the condition of the rivers. The most malarious portion is that forming the low-lying, ill-drained Kalantar land. This has been due not merely to the decay of the rivers but also because several embankments have been built up for the purpose of roads and railways which interfere still more with local drainage. Enquiries by

* C. A. Bentley, *Malaria and Agriculture in Bengal*, p. 10.



Raja Digambar Mitter and others show that malaria closely followed the construction of railway embankments in Shimurali, Chakdah, etc. Bentley observes, "Recent observations have shown on numerous occasions that, following the construction of embankments, there is a very great local extension of Malaria on both sides of the embankments, accompanied by a rise in the local mortality, an increase in the proportion of fever cases and fever deaths and a rise in the spleen index. . ." *

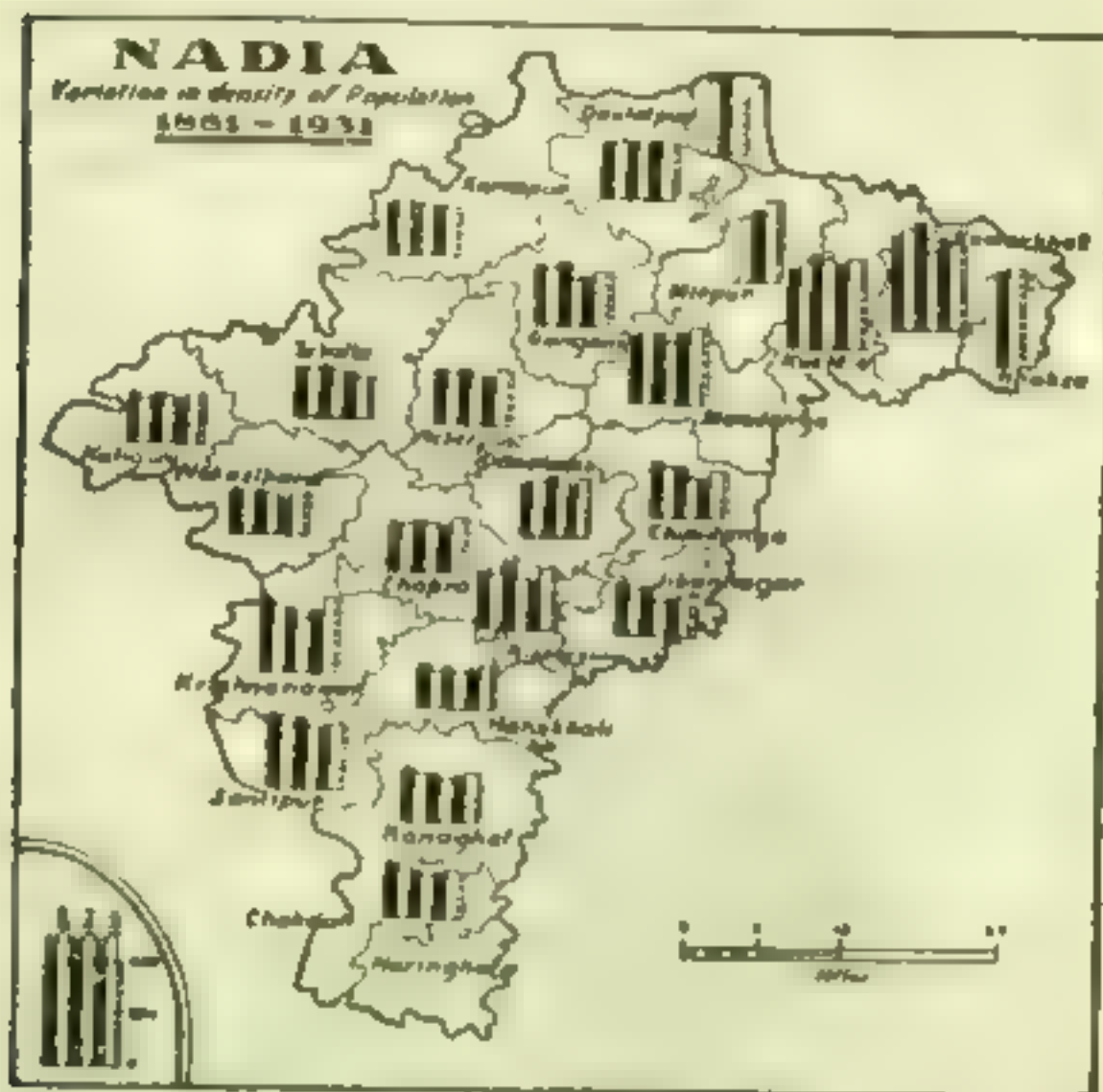
140. So the total effect in the above changes in environment has been that—

- (i) the area has grown insalubrious ;
- (ii) the fields have become impoverished ;
- (iii) the return of crops have gone down ;
- (iv) the subsoil water has risen higher, with its consequent effect of increasing water-logging and of incidence and spread of malaria.

141. This change in the ecological conditions also finds reflection in the readjustment through decreasing density which became necessary. "There seems little doubt that the main reason why the percentage of the population engaged upon agriculture is so comparatively low in Nadia is that the land is on account of its

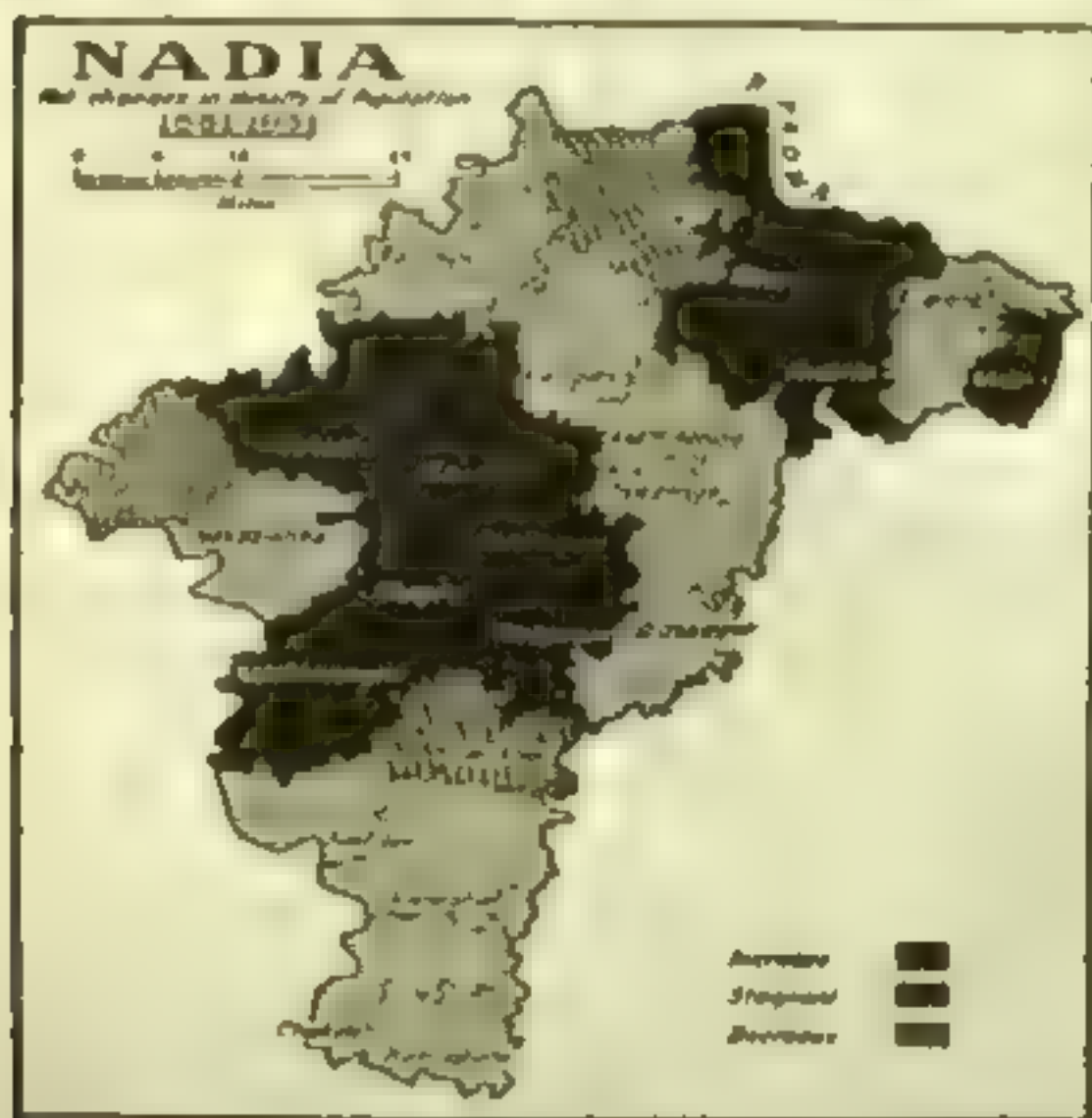
* C. A. Bentley, *Malaria and Agriculture in Bengal*, p. 26.

infertility, incapable of affording a livelihood to a larger percentage."



142. If the graph showing the variation of population from 1881 to 1931 be observed, it will be found to be undergoing a steady decay. In 1881, the population was 16,62,795, and in 1931 it came to be 15,29,632. The graph does not show any abrupt variation from the horizontal

except in the year 1921 (the year of the Influenza epidemic), indicating that the decline has been steady, due to inherent ecological causes and not to natural calamities. Similar observations also apply to the graphs showing the density for the



different police stations. The variation in density for the district as a whole has been from 595 to 531. Though it shows a slight rise between the years 1921 and 1931, the reason is perhaps due to

recuperation from the epidemic. Only Mirpur, Kushtia and Alamdanga show some signs of improvement in the last decade, and it should be noted that they are benefited by inundations, however irregular, of the Garai and the Kumar. Concerning ecology and the rise and fall in the graphs between the years 1921 and 1931, the following observations in the *Bengal Census Report*, 1931, will be of help :—

“ In Ranaghat and Chuadanga there has been decrease . . . Ranaghat . . . described . . . unhealthy subdivision . . . Decrease in Ranaghat, Chakdah and Haringhata P.S. is accounted for by . . . resulting in emigration of middle class . . . ”

Decrease in Damurhuda and Jibannagar, “ ascribed to general unhealthiness, attributed in Jibannagar mainly to the decay of effluents of the Ganges passing through these Police Stations.”

“ In the Sadar Subdivision, which shows the largest percentage of increase (61), only one police station, Hanskhali, has recorded a decrease, and in this area, which is reported to be notoriously malarious, many people have left their homes.”

The important result following the improvement of health and water supply will be appreciated from the fact that “ During the decade a filtered water supply was installed by the Municipality of Krishnagar, which has had the



influence of increasing the health of the town and attracting middle class residents from rural area to settle there. . . ."

JESSORE

143. Jessore follows Nadia and adjoins it to the south-east. "It consists of a wide alluvial plain intersected by numerous rivers, which again are connected by interlacing cross channels, called Khals."* The general nature and the drainage of the district has thus been noted in the *Bengal District Gazetteers—Jessore*, p. 2 . .

"The district falls naturally into two main divisions with distinctive physical characteristics, the country to the north and west being above flood level and fairly dry, while the south and south-east are low-lying and dotted with large marshes. If a line be drawn from Keshabpur on the Harihar river south of the town of Jessore, to Muhammadpur on the Madhumati, it will be found that the lands which lie to the north and west of the line are generally high with a slightly sandy soil and free from inundation. The general fall in the level of the country is from north-west to south-east, and the river channels and lines of drainage follow this direc-

* *Bengal District Gazetteers—Jessore*.

tion. . . The tract to the south and south-east of this imaginary line is intersected by channels in all directions, and there are numerous swamps. . . The river flows backwards and forwards according to the tides, and for some months in the year the whole country is practically under water. There is no definite line of drainage, and the water, when it does drain away, finds its way out in whatever direction local circumstances may determine."

144 All the rivers that have been mentioned in case of the district of Nadia, excepting the Mathabhanga and the Churni, flow through Jessore. It has already been discussed that, excepting the Garai, the Kumar and the Ichamati, all other rivers (Nabaganga, Chitra, Bhairab) have ceased to function as carriers of silt, their offtake with the parent river having silted up. The Betna and the Kabodak look to the Bhairab for their water supply and get little. The result is that in their upper courses, roughly to the north of the line from Keshabpur to Muhammadpur, the rivers are no more than mere drainage channels. "Thus part of the district now receives little, if any, flood water from the Ganges, and the channels have greatly deteriorated and are full of weeds, they are useful only for local drainage, the volume of which is small and in no proportion to their natural capacity of discharge" (*Bengal District Gazetteers—Jessore*, pp. 2-3).

The lower parts of the courses of the rivers south of the above imaginary line are flushed by tidal action, with the consequence that the channels have not decayed. But this flushing neither helps in depositing silt nor in increasing the fertility of the fields.

145 " It is reported that cultivation has suffered from the deterioration of the rivers, which year by year used to deposit a layer of silt on their banks and in the *bils* during flood time. . . . This natural form of fertilisation has ceased. . . The area under *Aman* rice is contracting owing to deficient floods " (*Bengal District Gazetteers Jessore*).

" Agricultural deterioration — Large tracts in Magura, Narail and in the Sadar Subdivision of Jessore are showing signs of permanent deterioration owing to want of facilities for the ingress and egress of rain and flood water " (Remarks from Annual Season and Crop Reports by the Director of Agriculture)

Commenting on the above two quotations, Bentley remarks, " The last quoted extract above is extremely significant, summing up as it does in a few words the main causes of agricultural decline in the district of Central Bengal."

146. This shutting out of river water had its effect on health as well, a fact borne out by the following observation by Bentley, " . . .

shutting out of the river water from the surface of the delta was further marked by the simultaneous occurrence of appalling epidemics of malaria, a serious decline of agriculture and the progressive depopulation of the affected areas."

147. Briefly, then, the conditions of environment are this: On the west and north-west, the rivers have become moribund and do



not continue to flush the area, or inundate it; to the south and south-east, though land building and fertilising action of the rivers are not to be

expected, they yet flush the channels by tidal action; to the east, bordering the Garai and the Madhumati, the conditions appear to be comparatively better, due to the yet active state of the rivers.

148. If the total population of the district as a whole be considered, the corresponding graph will indicate a steady but gradual decline from 1881 to 1931. The population in 1881 was 19,39,375, and that in 1931 was 15,71,164. The density curve for the entire district for the same period also follows the same trend as that for the population. When the density graphs for the individual thanas are considered, it is found that all of them show a steady decline except in the thanas of Lohagara, Alfadanga, Sripur and Salkopa. It is interesting to note that these thanas, which show some increase in population, are on the borders of the Garai-Madhumati and are thus benefited by inundations of the river. This also finds support in the following observation :—

“ The Jessore district has for some time been an area in which the population has been decreasing, and in every instance the cause is ascribed to the action of the rivers. Where they flow strongly, they not only provide irrigation for the fields but also communication for trade. In the west and central parts of the district,

however, the offshoots from the Ganges have decayed and no longer flow freely, with the result that local trade and commerce have been hampered and land tends to go out of cultivation and to be covered with jungle' (*Bengal Census Report, 1931, Vol. V. pp. 44-45*)



"The density along the eastern margin is comparatively high, and on the southern border against Khulna it is also very much higher than in the middle and west of the district. It is

lowest in Bongaon subdivision, rather heavier in the centre of the district, but decreases again to the east, before the more densely populated area served by Garai and the Madhumati is reached " (*Bengal Census Report, 1921, Vol. V, p. 57*).

149. Thus, adverse changes in the ecological conditions usually proceed very slowly. People can fight them or make such adjustments by which the decrease in the sustaining capacity of the land might be compensated by artificial means, thus maintaining former density of population. In case of Jessore, however, as appears from the decrease in the density of population, none of the above methods were followed and the result was that the land came to sustain a gradually lower density of population in successive decades.

CHAPTER XII

ECOLOGICAL CONDITIONS IN AN
AREA PARTLY MORIBUND AND
PARTLY ACTIVE

FARIDPUR

150. In the case of the districts of Murshidabad, Nadia and Jessore, previously discussed, there was little difference in the physical features in the different parts. In case of Faridpur, however, different parts present quite unlike features

Drainage.

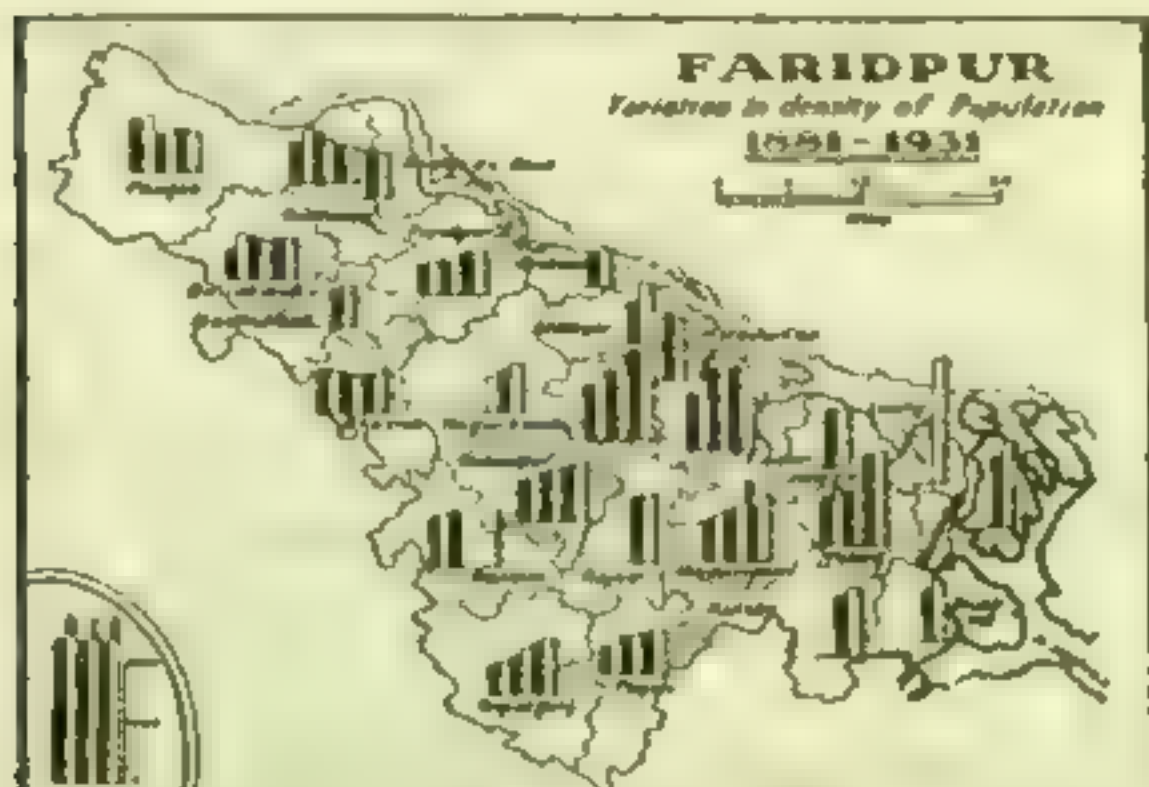
" In the north, the land has been raised by the deposit of river silt and is comparatively high and dry except during the rainy season. The *north-western* extremity, in the Goalundo subdivision, resembles in many respects the adjoining portions of the Districts of Nadia and Jessore rather than Eastern Bengal. In the *south-east*, there is a tract of new alluvium with a network of channels which the Ganges has left in its passage eastward. . . . In the *south-east*, lying in the Gopalganj subdivision, the level sinks and the country consists of a chain of marshes (*bils*) with strips of high land formed of silt deposited by the river which have from

time to time flowed or still flow through this tract. This low lying area is mostly under water for three-fourths of the year, . . . " (*Benpul District Gazetteers—Faridpur*, p. 2)

151. Starting from the north west, Garai-Madhumati is the first river encountered. It still continues to be active, and can spread silt in the adjacent regions only in times of high flood. Between the Garai and the Padma, which forms the northern boundary all along the north and subsequently combines with the Meghna to form the Meghna estuary, a number of rivers, Chandana, Kumar and Barasia, are found almost dead or dying. Little Ganges water now passes down them and action of land building has come to an end. " Shoals, however, have formed at the mouths of the distributaries which connect with the marshes, and it is only at the height of the flood that silt-laden water can come into them and carry on the process of land formation."

152. Along the northern border, the Padma is very active and is constantly building up new *chars* at one time, only to sweep them away at another. The Arnalkhan, which is still active with its system of distributaries, the Bhubaneswar, Safepur, Noabhanguni, etc. and the Meghna, are constantly bringing enormous quantities of silt and enriching the soil in the intervening tract. This part of the district shares the active stage of land building.

In the southern part of the district bordering Barisal, there is a vast area of water or *bil*, which is gradually being filled up by the Madhumati, Chandana and the Kumar.



153 From a study of the state of the rivers in the different portions of the district, we can safely presume that the land would show decreasing fertility and growing unhealthiness in the north-western part of the district. Bordering on the Padma and also in the area between the Analkhan and the Meghna the land should be rich, healthy and better in climate.

It will also be healthy in the area of *bils*, "because they never dry up, leaving large areas

of shallow mosquito breeding pools, and they may be useful reservoirs of drinking water " (*Report of the Drainage Committee*, 1907, p. 24.)

154. If now the graphs showing the density of population by thanas be examined, it will be found that—

Nature of change
of density

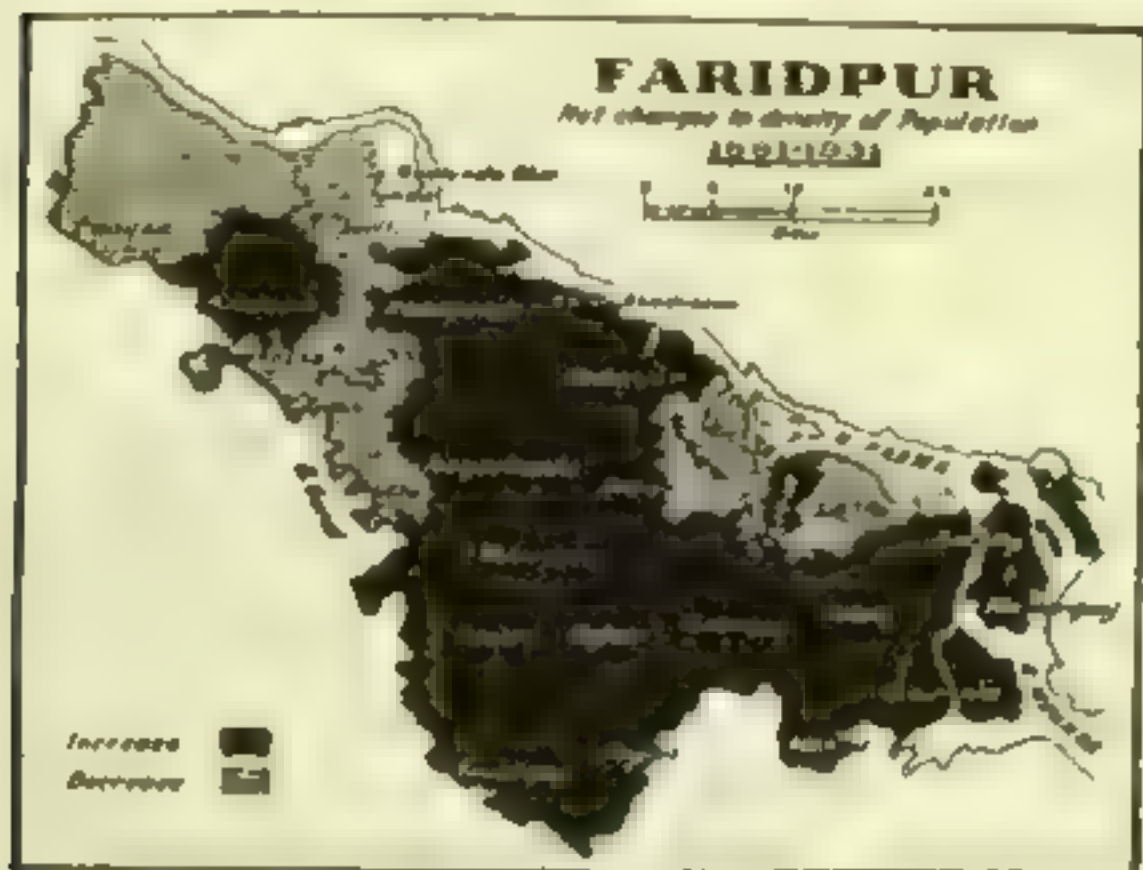
(i) Pangsa, Goulundo, Bahakandi, Madhukhal, Blusna, etc., situated towards the north-west, show a stagnation in density between the years 1881 and 1931;

(ii) the thanas of Bhedarganj, Bhanga, Silchar, Gopalganj, Pinjuri, etc., situated in the east or south, have an increasing density;

(iii) Some of the thanas bordering on the Padma and the Meghna, like Matbarerchar, Char Bhadrasan, etc., though situated in the region of active delta, do not show a considerable rise, which has been accounted for by the fact that the land has not yet been firm enough to encourage habitation.

155. Thus, we find that three different types of environment, even within the small compass of a single district, have affected the distribution of population in different ways. In the north-west where the delta is growing moribund, the population is stagnant, while in the other areas it is improving. Another interesting fact brought out in the south of the district is that even *bil* areas (not swamps) can support a large

density, because they do not breed malaria, supply good drinking water, fertilise the fields



when dry, and also provide abundant fish to the inhabitants.

CHAPTER XIII

ECOLOGICAL CONDITIONS IN A MATURE
AREA

24-PARGANAS

156. In the different parts of the 24-Parganas, the slope and drainage conditions are found to be different. Bordering the rivers Hooghly and the Jamuna are two strips of well raised banks, from which the land slopes inland towards the centre of the district. The drainage also follows the same course. In the northern and central portions of the district, there is imperfect drainage, which has given rise to a number of swamps and *bils*. These are no longer being filled up, as the redistributaries of the Ganges, flowing through this area—Adiganga, Piali, Bidyadhari, etc. have ceased to receive their former quota of silt water. Coming to the south, in the areas of the Sunderbans, where the mouths of all the channels are kept open by tidal action, the drainage is seaward, towards the south. Thus, within the short compass of a single district, we find several stages of land building.

157. The Hooghly distributary on the west is the only active stream, and its redistributary, the Jamuna, on the east is merely flowing from whatever water it receives from the Mathabhanga or the Ichamati. Surrounding the banks of these rivers, raised high above the adjoining region, the conditions are healthy because the area is better drained, and a fair supply of drinking water is available there.

158. In the northern and central portions, the conditions are the same as in Nadia or Jessore, where the rivers have grown moribund and do not even supply a fair amount of drinking water, not to speak of silt and inundation. The result is that lands are infertile, and jungle and malaria are more prevalent in this part.

159. The southern thanas bordering the Sunderbans, though not now in the active stage of deltaic formation, have been improved by a better system of drainage, known as the Magrahat Scheme. Trees and under-growths have also been cut down.

160. In the southernmost part, in the Sunderbans, where the land has not yet been sufficiently well raised and the problem of salinity is a knotty one, the conditions are comparatively better in the neighbourhood of those rivers which bring a sufficient amount of fresh drinking water. The populations are dense in these parts.

161. From the above description of land, drainage conditions, and availability of drinking water, the following areas, then, can be expected to support high density—

Areas that can support high, low or medium density

(a) Thanas bordering on the Hooghly and the Ichamati. Some of those bordering on the Hooghly are Naihati, Nawabganj, Barrackpore, Khardah, Baranagar, Budge Budge, and also the suburban areas of Calcutta and the city itself. The additional interest in these places is the trade and the facilities of employment in mills, etc. Those on the Ichamati are Baduria, Basirhat, etc.

(b) The northern and central thanas would support a stagnant or even decreasing density. Some of them are Habra, Deganga, Barasat, Dum-Dum and Tollygunge.

(c) The density in the southern area, benefited by the Magrahat Drainage Scheme, ought to show an increase in density.

162. If now the graphs showing the density, in different decades from 1881 to 1931, of the different thanas mentioned above be compared, they would be in perfect agreement with the expected results.

Nature of change of density

The thanas Naihati, Barrackpore, Budge-Budge, all indicate a steep rise in the graphs, excepting Baranagar and Khardah, where the rise is much more gentle. The steepness in case

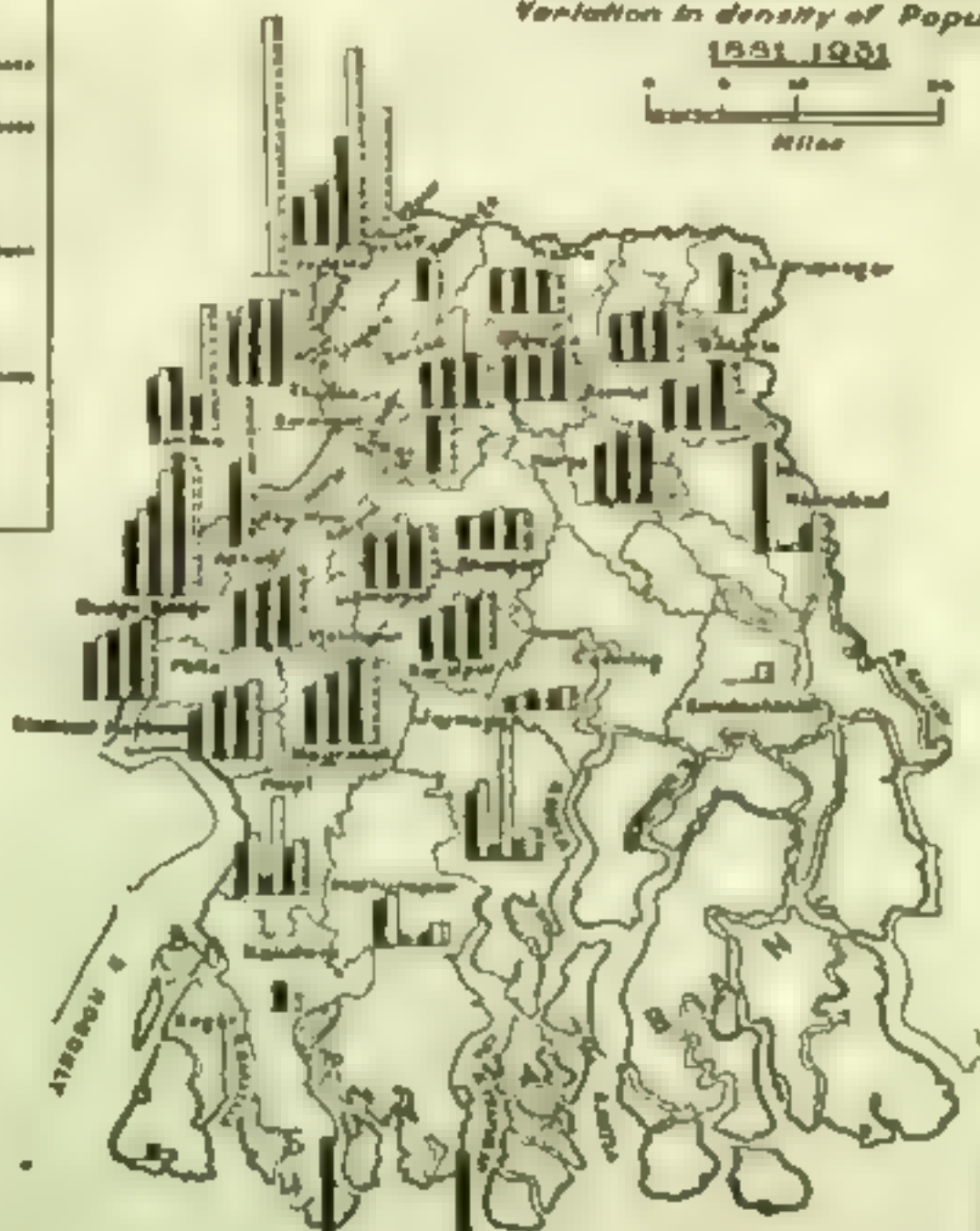


CALCUTTA

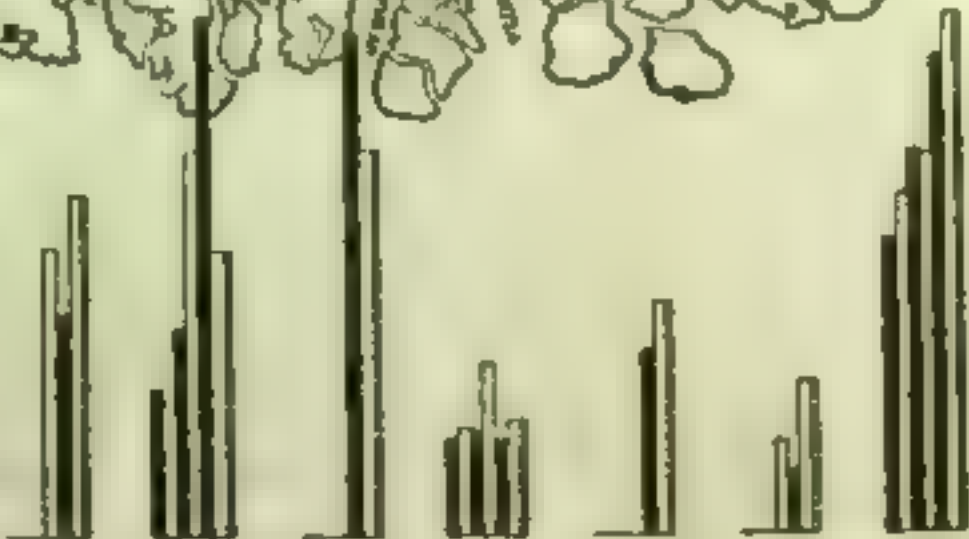
24 PARGANAS

Variation in density of Population

1881-1931



ATBODON



Baranagar Baranagar Baranagar Baranagar Baranagar Baranagar Baranagar

of the former thanas has been largely due to the immigration of labourers in the mills. The "only thana losing ground" in this part is Nawabganj," and it is reported in the *Bengal Census Report, 1901*, that a mill had to be closed down due to its unhealthy conditions.

The thanas Baduria and Basirhat, on the Ichamati, also maintain a steady rise in density.

163. Thanas indicating an arrested growth, as apparent from the graphs, are Habra, Deganga, and Barasat. Tollygunge has shown some improvement, which would be more marked in the next decade (1931-41). It will be mainly due to the improvements undertaken. Similar is the case with Dum-Dum.

Density of population has been rather steady, and there are signs of even some improvements in the thanas Bhanger, Barunpur, Bishnupur, Falta, Diamond Harbour and Magrahat. The graph for Haraon only shows a decrease, due to its insalubrious conditions.

164. Though the graph showing the total population in successive decades from 1881 to 1931 shows a steep rise from 23,03,078 in 1881 to 40,74,583 in 1931, those for many of the police stations, especially in industrial and unhealthy areas, show great fluctuations. The reason in case of the former is that when industries are affected, the numbers of labourers fluctuate, and this is reflected in the density. People from

24 PARGANAS

Net changes in density of Population

1881-1931



unhealthy thanas sometimes migrate, and at other times immigrants come up to take possession of the vacant land, and this also causes fluctuations in density.

165. The density is gradually increasing in the Sunderban regions, where reclamation is going on. That in Hasnabad, Haroa, etc., which had formerly been in decay, due to the moribund condition of Haroa Khal and the Jamuna, is now showing improvement, due to above reasons. The net rise in density for the district as a whole has been from about 310 in 1881 to 516 in 1931.

KHULNA

166. Khulna resembles 24-Parganas in that its different parts have different conditions. To the north-west of a line joining Basantapur with Khulna town, i.e., roughly to the north-west of the Kanksali and Rupsa Khals, the nature of the country is similar to that of Jessore. The rivers in this region have ceased their action of land building and have confined themselves within banks. They are no help to the soil and the country.

The north eastern portion, between the Jessore Khulna boundary and the town of Bagerhat, is rather low lying, and the only high places are the river banks or the levees.

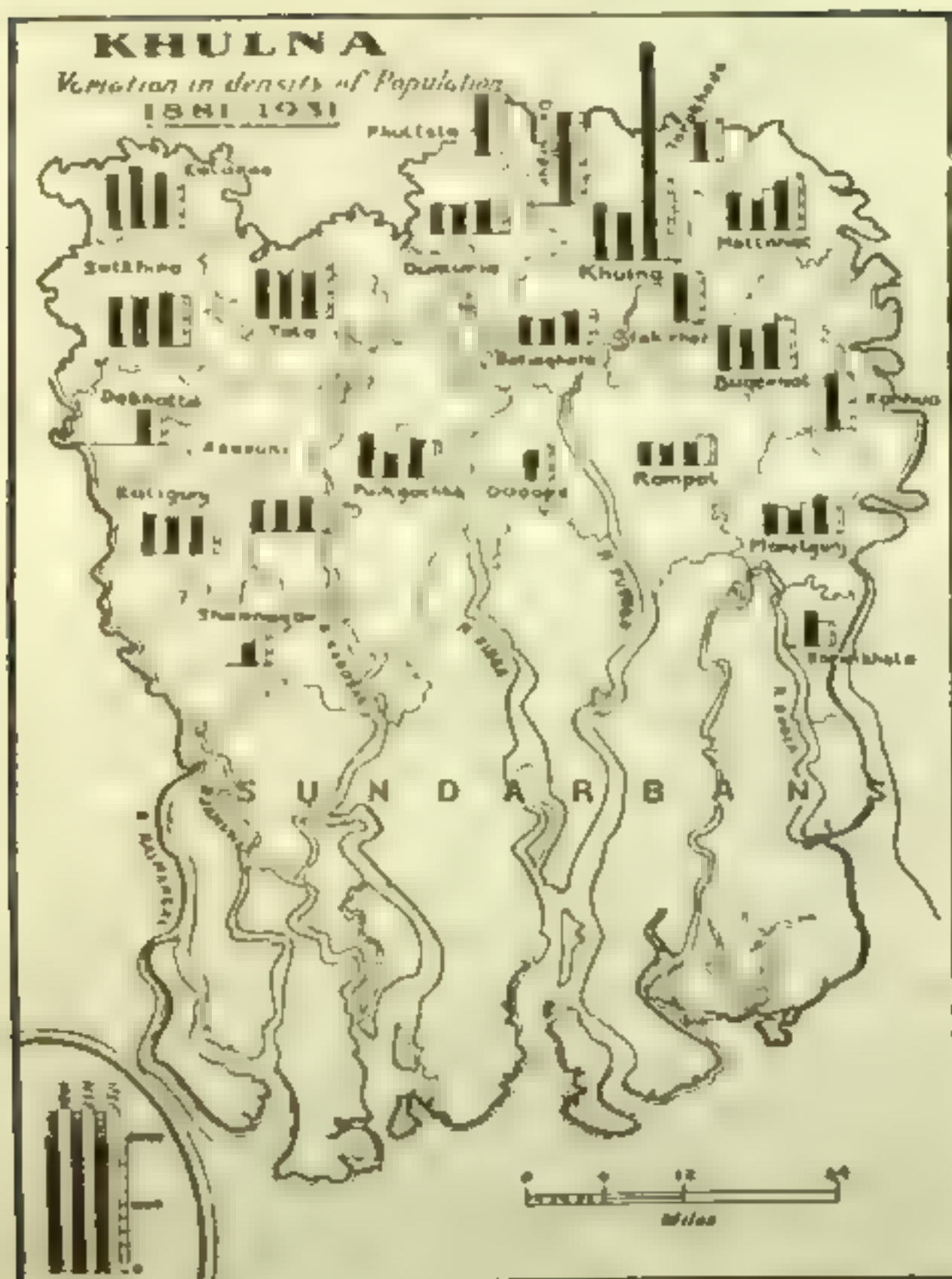
The central region is a low-lying land, continuing down to the Sunderban regions, where tidal estuaries maintain a flush.

167. Beginning from the Jamuna on the west, all the distributaries and re-distributaries — Betna, Bhairab, Kabodak, Bhadra, Atharabanki and their continuations southwards — have ceased to maintain communication with the Ganges and are now no more than mere drainage channels, only kept flowing by the reception of local run off. The Madhumati, the continuation of the Garai southwards, is still active and carries a large quantity of silt from the Ganges and it is only near its banks that land building and inundation with silt water are proceeding.

In the central portion of the district, and further to its south, the creeks become brackish in the summer, and turn sweet in the rains when fresh water from the north forces the salt into the sea.

168. From the above details, one can expect the population to be almost stagnant or rather decaying in the north-west, the region of mature delta which has recently ceased to be in the active state. The graphs showing the density in the thanas of Satkhira subdivision — Kalaroa, Debhatta, etc — support this. It is also mentioned in the *Bengal Census Report, 1931*,

Nature of change of density



that "... the decline in the Kalaroa and Satkhira police stations is ascribed to the silting up and deterioration of the rivers and *khals* once forming the natural drainage of the areas. The population of Debhatta police station has remained practically stationary." The considerable increase in this area in Shamnagar has been due to addition to the area.

In the north-eastern part of the district, bordering on the river Madhumati, which still carries enough salt, inundating the region, the population ought to show some increase.

The graphs for the thanas of Mollahat, Kachua, Morrelganj, etc., all show a rise in density. The *Bengal Census Report, 1931*, also observes that the increase in these areas has chiefly been due to natural causes and also to fresh areas of cultivation being opened up.

The central region is a land of *bils*. Though the *bils* are not inviting in themselves, yet they do not make the environment insalubrious, owing to their open nature. The density in the thanas in this area has remained almost steady or is slowly rising.

The graphs for the thanas of Asasuni, Batiaghata, Dacope, etc., run steady, with a turn in later years to the upward direction. The curve for Paikgacha is rather peculiar. Its steep descent in the year 1901 is due to the ravages of a cyclone, and the subsequent sharp rise in

1911 has been partly due to the return of former inhabitants and partly for extension of agriculture. The steep rise for the graph of Khulna in 1921 is due to the opening of the steamer route *via* Khulna, and its fall in 1931 is due to the desertion of the same.

169. The population is very slowly extending, in the northern border only, of the Sunderbans region, due to reclamation, but is not extending into the forest region for three reasons, *viz.*, (i) the land is an area of protected forest; (ii) scarcity of sweet drinking water; and (iii) unstable condition of the land.

170. Since the area of arrested density is only confined to the north-west and is comparatively small the district has shown a steady rise in the total population (from 10,79,948 in 1881 to 16,26,148 in 1931), as the relevant graph shows. The graph showing the variation in the density of the district as a whole also runs parallel to the above.

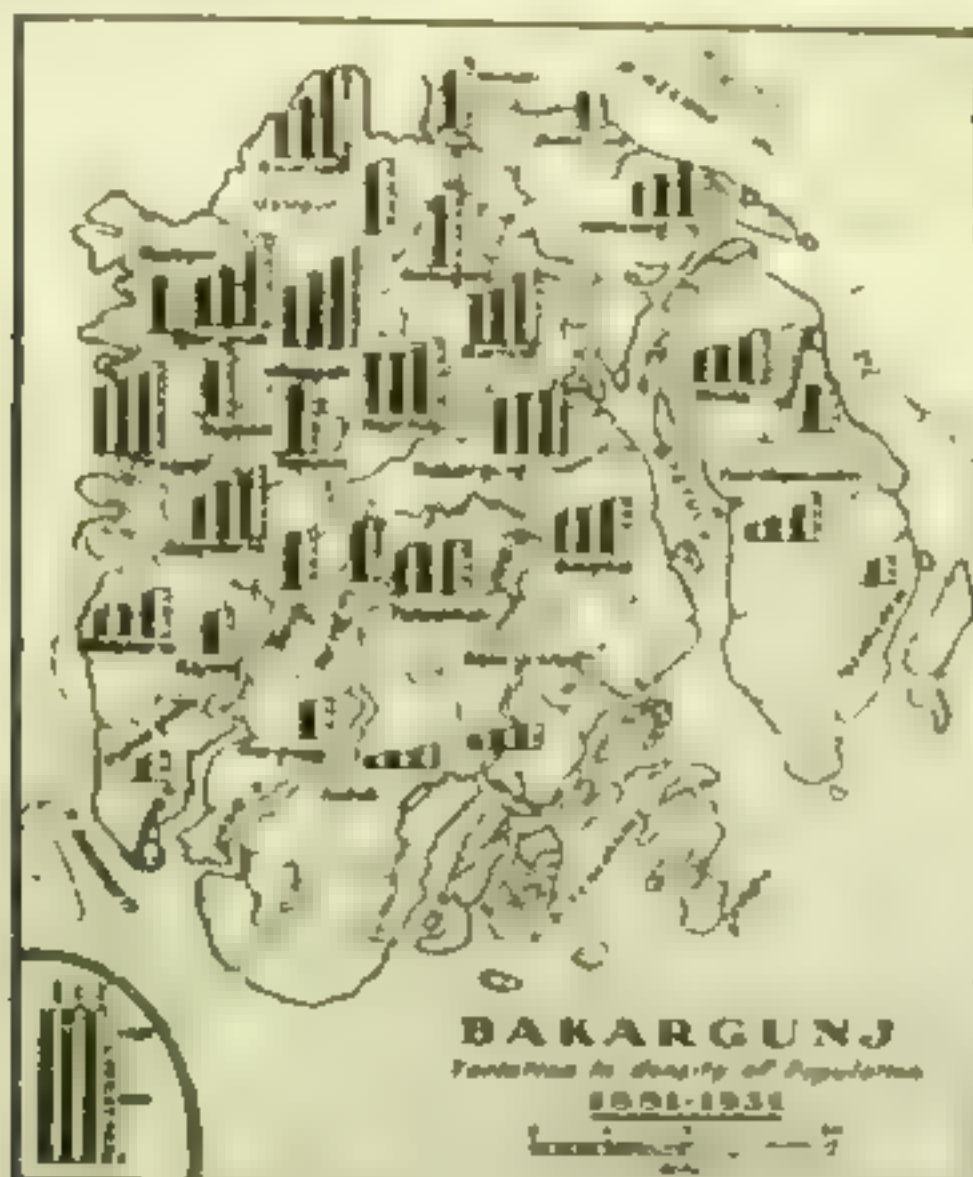
CHAPTER XIV

ECOLOGICAL CONDITIONS IN AN ACTIVE AREA

BAKARGANJ

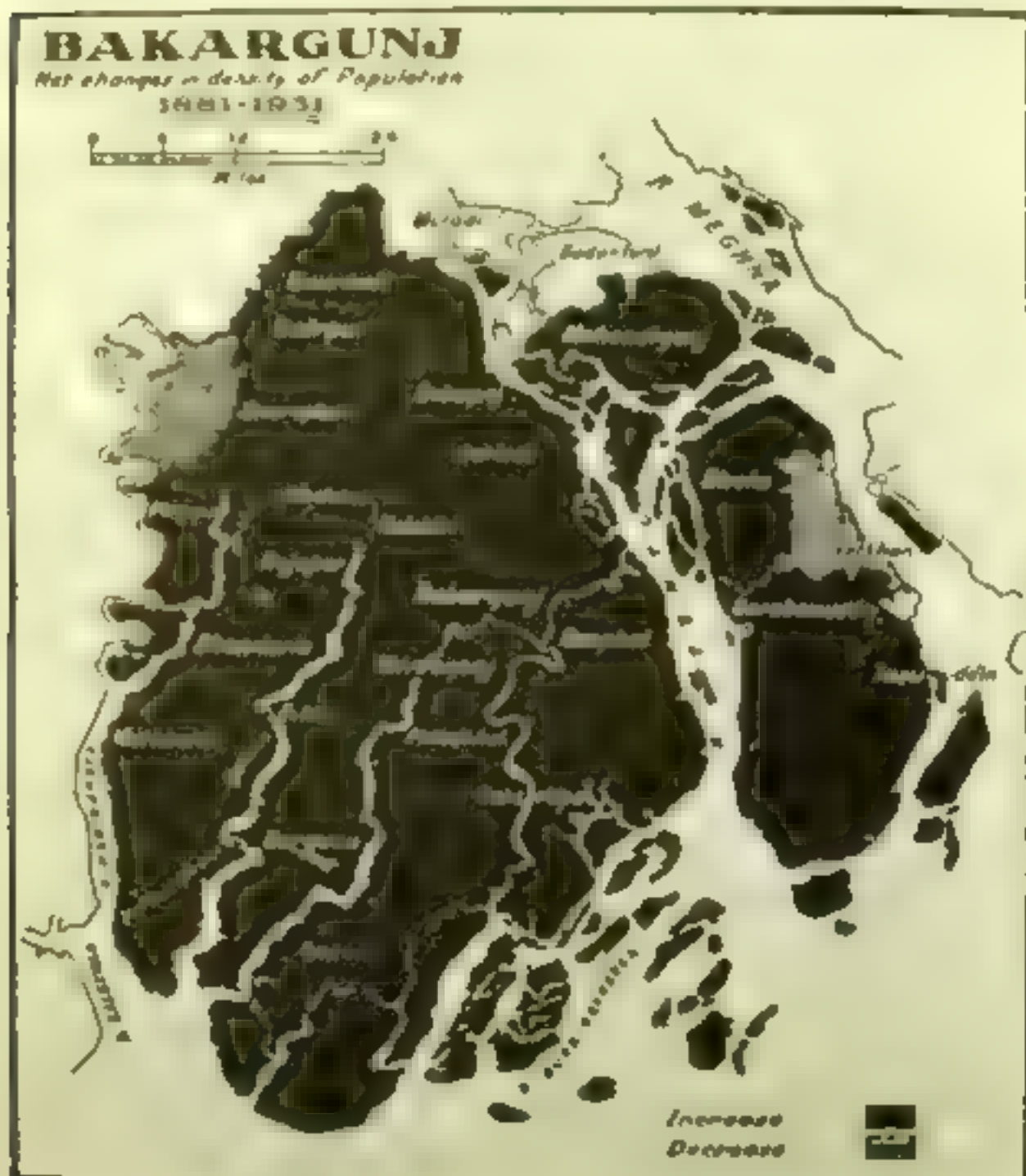
171. Bakarganj forms the easternmost district of the deltaic region, after which come the Noakhali islands. The entire region is an alluvial formation still in the active stage of land building. It is only the island of Shahabazpur that is above the level of high tide. The rest of the district, the mainland with the island fringes, is generally below the level of high tide, and, as a result, "during three months in the flood season, is for the most part entirely under water." The process of flushing is ideal, because, when the flood subsides, the area under water of the entire region gradually contracts, till it is perfectly drained out. This is possible only for the reason that the rivers have not yet thrown up any levee, nor have embankments without providing for adequate channels been built up to take roads or railways across the directions of drainage. The water ways of this district make good the absence of roads and railways.

172. The whole area benefits from the inundations of the distributaries, beginning from the Madhumati on the west to the Tetulia and the Shahabazpur on the east.



east, with the Meghna on the north. Moreover, these streams are interconnected by innumerable cross-channels that help in distributing the silt carried by the rivers over the entire area.

173. Little wonder, therefore, that no part of the district suffers from Health and fertility impoverishment and insalubrious conditions. It is on the sea face only, and



in the Shahabazpur island, in the extreme south, that want of drinking water is experienced and that the soil is impregnated with salt. This is the region of the Sunderbana. But a little to the north, the strength of the fresh water obviates this effect.

174. The district had a population of 19,00,889 in the year 1881, which rose to 29,39,050 in 1931. This doubling of population has been largely due to immigration, the fertility of the soil and its salubrious condition attracting large numbers. This steep rise in the curve for the variation of the total population of the district is also supported by that of the increase in the density of the district considered as a whole (521 in 1881 and 834 in 1931).

175. If the graphs for the density of the individual thanas be compared, all of them would indicate a steady and rapid rise except for the year 1911, when the majority of them indicate an equally steep descent. Such a steep descent, confined to one decade only, suggests some abnormal cause—which, in this case, was the devastating cyclone of 1909. The whole district suffered in this cyclone, but the southern portion of Dakshin Shahabazpur, Patuakhali and Pirozpur, more than any other. This is the only district where the rivers over the entire area are active and also where people find opportunity to make

progressive adjustment by extending cultivation and increasing density.

NOAKHALI ISLANDS



176. At the furthest end of the deltaic region, are the Hatiya and the Sandwip group of islands. In all respects they are akin to the Shahabazpur Island, excepting that the former islands are in a region susceptible to more frequent inundations.

The islands are in a very healthy state and the density is steadily and rapidly increasing

inspite of frequent inundations.* The graphs showing variations of density in Sandwip (from



281 in 1881 to 1196 in 1931) and Hatiya (from 218 in 1881 to 494 in 1931) also indicate the same thing.

* "Ramgati Police Station in the Sadar Subdivision has increased ... owing to migration from Sandwip and Sudhagram whose land^a had been eroded, although this migration is not sufficient to result in a decrease in the population of those last two police stations where there has been an increase respectively of 11.6 and 6.7 per cent."—*Bengal Census Report, 1931, p. 65.*

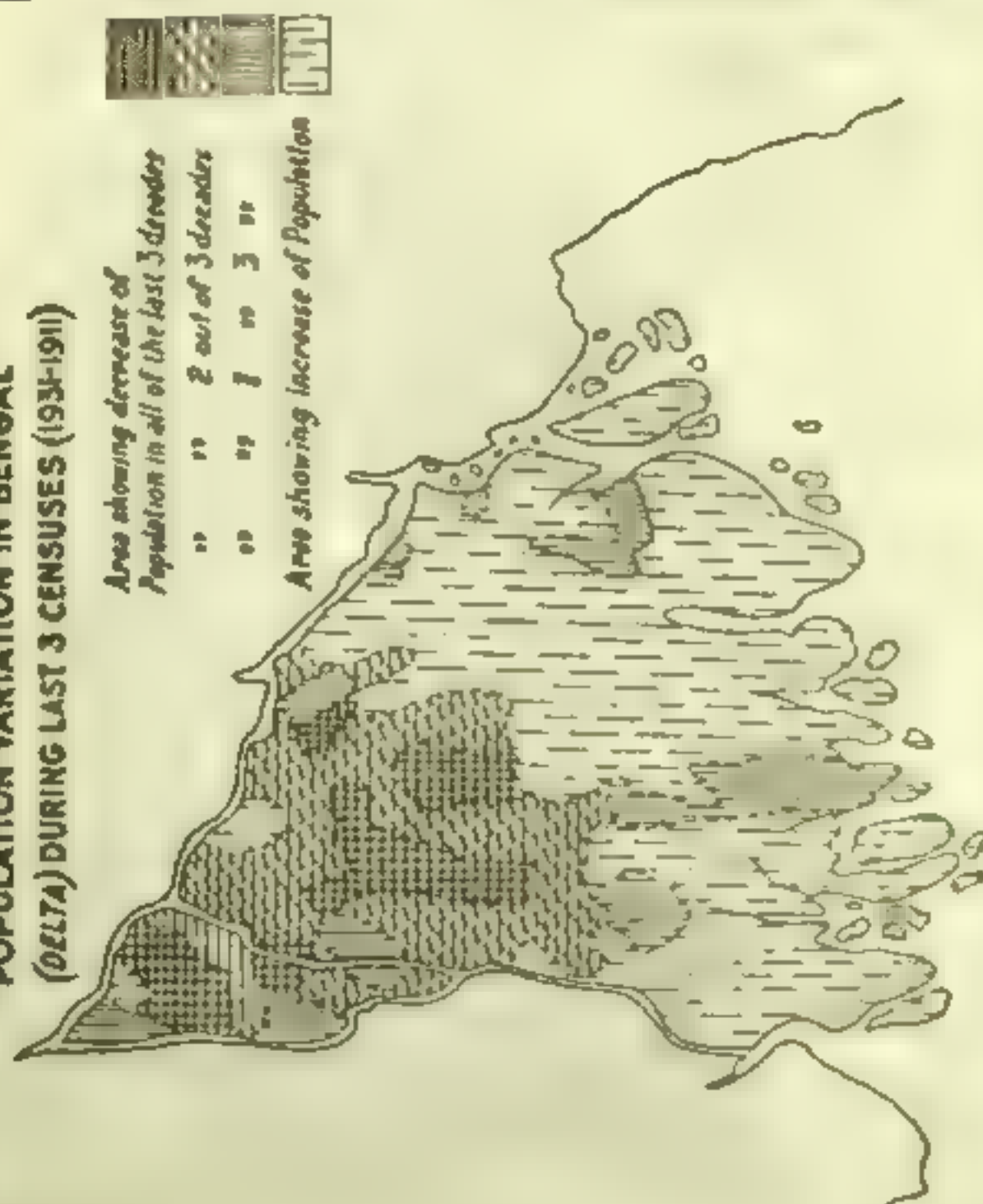
CHAPTER XV

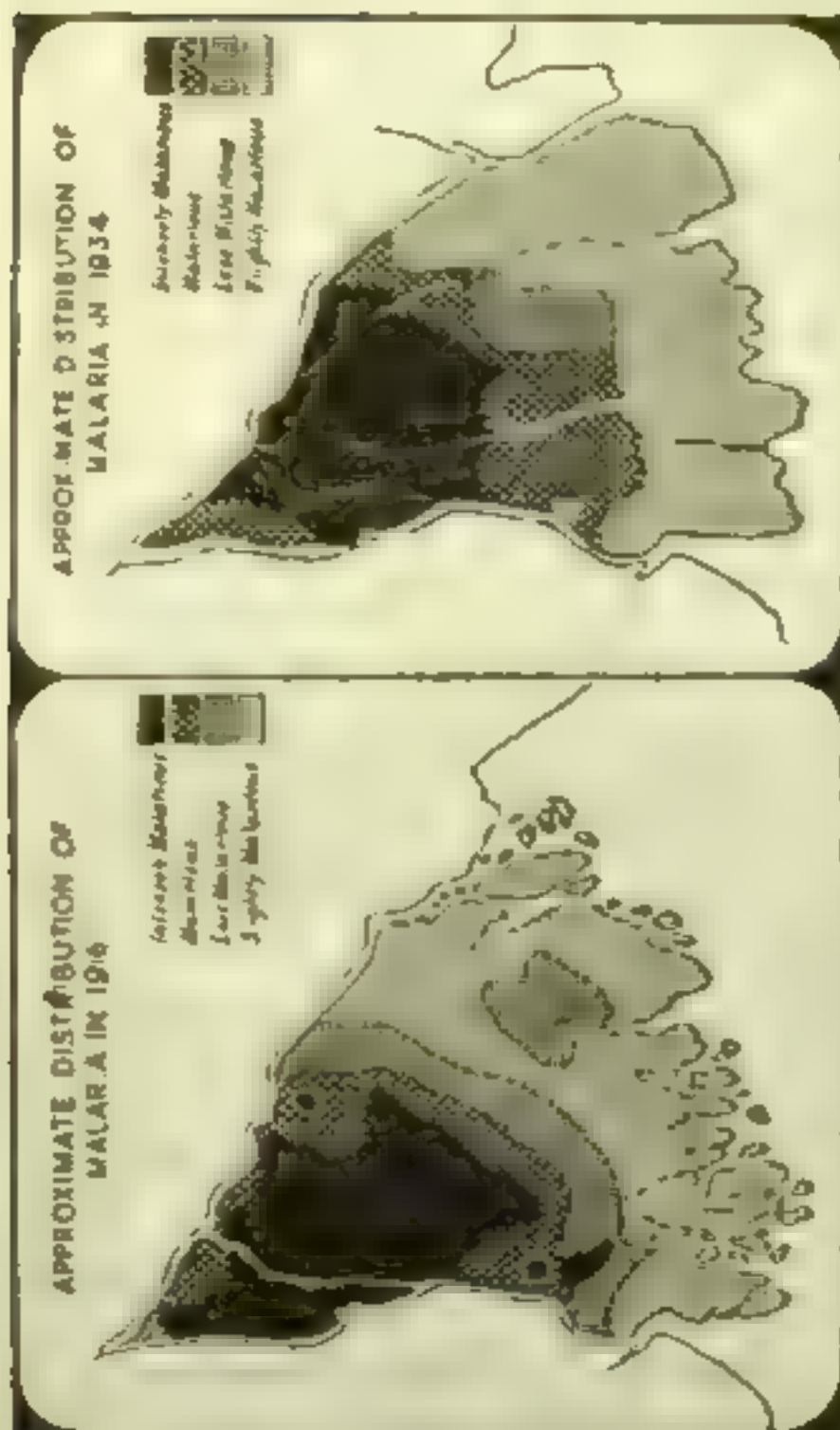
DISTRIBUTION OF POPULATION IN RELATION TO ECOLOGY : A REVIEW

177. From what has been discussed previously, it follows that the entire delta can be divided into three parts where hydrographic and physiographic characters vary. Such variation in ecology has also necessitated different kinds of adjustments, and as a result, population distribution, too, could not be uniform either in space or in time.

178. The northern part of the delta, comprising the districts of Murshidabad (eastern half), Nadia, Jessore, north-western part of Faridpur and northern borders of the 24 Parganas and Khulna, form a tract which has been termed the "Moribund Delta." The area was once prosperous when the rivers were active and used to innundate the land. The active stage of deltaic processes having migrated southward, the fields have become less fertile and the climate unhealthy. As a consequence, some of the parts are showing a decrease in population, whereas,

POPULATION VARIATION IN BENGAL (DELTA) DURING LAST 3 CENSUSES (1934-1911)





Reproduced from H. P. V. Townsend

in others, it is continuing stagnant. Little increases are observed when ecological conditions are found to have improved.

179. The 24 Parganas and Khulna (excepting the region of the Sunderbans) represent the mature stage in deltaic formation. The rivers do not carry enough silt now, nor the progressive stages of deltaic formations are markedly perceptible. The land supports a population fairly dense, but does not show a rapid increase except where urbanisation has masked the actual conditions.

When we come to the active parts of the delta, in the Districts of Faridpur and Bakarganj, where the rivers are still carrying on their function of alluviation and maintaining the health and the fertility of the soil, the density is considerably increasing. It is remarkably so in Bakarganj, where none of the thanas show any decrease in the last decade.

180. In the Sunderbans, the population is slowly increasing where reclamation is going on, but always in the vicinity of such rivers which supply sweet water for drinking purposes.



**Published articles of
Professor K. Bagchi
in Journals/Seminars etc**

**As per available record the list has
been made**

**It is an illustrative one
and not exhaustive**



Published articles of Professor K. Bagchi in Journals/Seminars etc.

Sl.	Author	Title of the paper	Journal	Year	Vol.	No.
01	Bagchi, K. N. K. Bose	Geography of the Sarakchandi Lake	Calcutta Geographical Review	1939	XX	2
02	Bagchi, K.	Kalimpang as Land & People	Do	1940	III	1
03		Kharwan An Ecological Study	Do	1941	III	3 & 4
04		The Flood Pro- blem As a sector Geographical Background	Do	1942	IV	2
05		Utilization of Indias Raw Material	Do	1942	IV	2
06		The Flood Pro- blem in India	Do	1943	V	2
07		The Adox 2000s	Do	1944	VI	2
08		The Mad Irrigation Project	Sci & Culture	1945 1946	VI	11



10	B. G. K.	Problems of Reclamation of the River	Do	1946	XII	8
11		Reclamation Irrigation	Do	1947 1948	13	
12		Agricultural Plans for a Population of Twenty Million	Do	Do	14	4
13		How the Problem River	Do	1948 1949	14	2
14		The Problem of Agriculture Reclamation	Geographical Research No. 3	1952	14	1
15		Problems of West Siberia Rivers	Do	1955	17	2
16		The Barents Mountains A Preliminary Study of the Problems	Do	1956	18	1
17		The Kama River Basin	Do	1957	19	1
18	B. G. K.	Problems of the Regions of East Kazakhstan	Do	1957	19	4
19	B. G. K.	Problems of the Development of Resource	Science & Culture	1956 1957	22	4



19	Bagchi K Sengupta Ashut Kr	Physiographic Regions of the Ranchi Plateau Bihar A Geographical study	Geog Rev of India	1958	20	1
20	Chatterjee S P Bagchi K	Hydrographic Features of the Ad. Ganga Bhumi	Do	1961	22	1
21	Bagchi K	Drainage Pattern in Ganga Jela	Do	1961	23	3
22	Chatterjee S P A Bagchi	Floods in West Bengal A Geographical Analysis	Do	1961	23	3
23	Bagchi K & Sen Usha	Gandhi's Growth & Landuse	Do	1963	25	4
24	Bagchi K	The Howrah Conurbation A Study in Urban Sprawl	Do	1966	28	1
25	Bagchi & Saha P K	Study of Crop Response to Soil Fertility in Rampurhat P S Birbhum Dx	Do	1967	29	1
26	Bagchi K & De N K	Soils of the Barh Kothari Tract with special reference to the Problems of Erosion and Conservation	Do	1967	29	1
27	Bagchi K	Problems of Regional Planning In the Durgam Valley Region	Soc & Cul	1967	33	9
28	Bagchi K	Gandhi and Economic Regeneration	Do	1968	34	1



29	Bagchi & Bhattacharya R	Drainage network in Karb Plateau, West Bengal.	Geog. Rev. of India	1968	30	4
30	Bagchi & Saha PK	Land Use Allocation on the Basis of Texture, the Soil and Slope of the Land in Dwarka Brahman Command Area in District Burdham	Do	1970		4
31	Bagchi K	Agricultural Problems & Its Solution through Interdisciplinary Measures Presidential Address	Do	1971	33	2
32		Thoughts on Planning presidential Address	Do	1972	34	2
33		Geography and its Social Application Presidential Address	Do	1973	35	2
34		Geographical Research in University Set up Presidential Address	Do	1974	36	3
35	Bagchi & Jana MM	The Crop Combination And Spatial Pattern of Land Utilisation in Lower Subah Basin	Do	1974	36	4
36	Bagchi K	Geography at the cross Roads Presidential Address	Do	1975	37	



37	Pal, S.K. & Bagchi, K.	Reccurence of Floods in Brahmaputra and Kosi Basins: A Study in Climatic Geography.	Geog Review of India	1975	37	3
38	Bagchi, K.	Role of Geographical Societies and Journals In National Developments.	Do	1976	38	3
39	Bagchi & Sen Jyotirmoy	Prehistoric and Historic Settlements of Birbhum, West Bengal.	Do	1976	38	4
40	Bagchi, K.	Relevance in Geographic Study and Research-A case for Restructuring of Geography Syllabi from Secondary to Post-Graduate level. (Presidential Address)	Do	1977	39	4
41	Bagchi & Ambastha, S.C.	Forests of Magadh - Geographical Analysis for planning.	Do	1978	40	1
42	Bagchi, K.	Landuse and Ecosystem (Presidential Address)	Do	1978	40	3
43	Bagchi, K. & A.R. Ghosh	Terrain in relation to Agriculture in India (Problems of Agricultural Growth in India.)		1978		



44	Jana.M& Bagchi.K	Hierarchy of settlements in lowers Silabati Basin	Geog Review India	1978	40	4
45	Chatterjee, Srikumar & Bagchi.K	An Analytical study of the transport system of the Sunderbans Region	Do	1979	41	1
46	Bagchi.K	Agriculture in the Draught Prone Areas (Presidential Address)	Do	1979	41	4
47	Barta, Debabrata & Bhattacharyya, Susmita, Bagchi.K.	Geo-Ecology of Digha- Contai Littoral Zone.	Do	1980	42	1
48	Bagchi.K.	Urban Renewal-Some Thoughts. (Presidential Address)	Do	1980	42	3
49	Bagchi.K	Area Development Planning in Doldrum (Presidential Address)	Do	1981	43	3
50	Bagchi.K	Transfusion -A must for the Bhagirathi-Hooghly. (Presidential Address)	Do	1982	44	4
51	Bagchi.K	Golden Jubilee Welcome Address	Do	1983	45	1
52	Bagchi.K	Geo-environmental Considerations	Do	1984	46	2



53	Bagchi.K	Basin strategy for Integrated Development of resources	ILLEE	1984	7	1
54	Bagchi.K	Environmental Planning - An Ecological Approach	Geo. Review of India	1985	47	3
55	Bagchi.K	Ecodevelopmental Features of Ganga Basin (Presidential Address)	Do	1986	48	3
56	Bagchi.K	The Studies On Landuse In Selected Regions of Eastern India.	Do	1987	49	3
57	Bagchi.K. & T.M.Das	Socio Economic Study of the stretch from Bally to Bandel.	The Ganga- A Scientific Study.	1991		
58	Bagchi.K	The Unstable Earth And its Environmental Challenges.-Keynote Address	Fifth conferenc of Indian Instt of Geomorp hologists.	1993		
59	Bagchi.K	Panchayats& Planning	ILLEE	1993	16	2
60	Bagchi.K	A time to ponder	Do	1993	17	2
61	Bagchi.K	The Geographical Review In The Service of Indian Geography.	Geo. Review of India	1998	60	3
62	T.M.DAS &	Environmental awareness and Socio-Economic Study	Man & Environment	2000	Vol II	



	Bagchi.K	of the River Valley Development with special reference to the Ganga basin.	August,2000.			
63	Bagchi.K.	Keynote address International seminar on changing environmental scenerio of India and adjacent countries since independence.	12th Annual Conference of Indian Institute of Geomorp- -hologists	2000		
64	Bagchi.K. &S.C.MU Kherjee	Recent Trends in Fluvial Sedimentological Analysis of Unstable terrain of the Himalaya and Ganga Plain. INDIA.	ILLEE	2002	25	11

The other published works under the editorship :

1. The Bhagirathi - Hoogly Basin
2. The problems of Agriculture growth in India
3. Problems of Regional Development and planning

The diagnostic survey of West Bengal under the financial assistance of the Govt. of West bengal had been carried out under his Directorship and the series of the research publications came out jointly with Sri K. N. Mukherjee are the following :-

1. Diagnostic Survey of Deltaic West bengal September 1978
2. Diagnostic Survey of Rarh bengal parts I & II - August 1974 and December 1980
3. Diagnostic Survey of West bengal (North) - February, 1983